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QUARTERLY

OF THE

National Fire Protection Association

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87 MILK STREET, BOSTON, MASS.

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National Fire Protection Association.

Executive Office, 87 Milk Street, Boston, Mass.

Members.

April, 1917.

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American Institute of Consulting Engineers.
American Institute of Electrical Engineers.
American Institute of Mining Engineers.
American Ceramic Society.
American Gas Institute.
American Electric Railway Association.
American Paper and Pulp Association.
American Warehousemen's Association.
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National Association of Credit Men.
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National Association of Insurance Agents, The
National Association of Manufacturers of United States.
National Assn. of Master Gravel and Slag Roofers of America.
National Association of the Motion Picture Industry, Inc.
National Automatic Sprinkler Association.
National Board of Fire Underwriters.
National Commercial Gas Association.
National Convention of Insurance Commissioners.
National Electrical Contractors' Association.
National Electric Light Association.
National Gas Engine Association.
National Implement and Vehicle Association.
National Lumber Manufacturers' Association.
National Paint, Oil and Varnish Association.
National Petroleum Association.
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New Jersey Schedule Rating Expert's Office.
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Ohio State Fire Prevention Association.
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Philadelphia Suburban Underwriters' Association.
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South-Eastern Underwriters' Association.
St. Louis Fire Prevention Bureau.
Suburban Fire Insurance Exchange.
Tennessee Fire Prevention Association.
Tennessee Inspection Bureau.
Texas State Fire Prevention Association.
Texas State Fire Insurance Commission.
The Union.
Underwriters' Association of the District of Columbia.
Underwriters' Assn. of the Middle Department.
Underwriters' Association of New York State.
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Underwriters' Bureau of New England.
Underwriters' Laboratories.
Vancouver Island Fire Underwriters' Association.
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Western Actuarial Bureau (Fire).
Western Canada Fire Underwriters' Association.
Western Factory Insurance Association.
Western Improved Risk Association
Western Insurance Bureau.
Western Sprinklered Risk Association.
West Virginia Inspection Bureau.
Wisconsin Inspection Bureau.
Wisconsin State Fire Prevention Association

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Reports on fires appearing in the Quarterly are copies of or extracts from written reports forwarded to the Association. This Association, as a body, is not responsible for the statements or opinions of any of its members.

Four blocks of fire ruins in million dollar fire, Asbury Park, N. J., April 5th, 1917. Material for a second conflagration of like character may be observed in the back ground.

"I would rather be careful a hundred times than get hurt once."—*Mark Twain.*

The Quarterly

Vol. 10 April, 1917 No. 4

Twenty-first Annual Meeting. The coming twenty-first annual meeting of the Association is set for May 8th, 9th, and 10th in Washington, D. C. The principal details of the meeting, hotel rates, etc., have been announced in the *News Letter* and the official program will be mailed as usual to members in advance of the meeting.

It is fifteen years since an annual meeting of the Association has been held outside of either Chicago or New York. The meeting of 1902 was held in Philadelphia. The members seem universally pleased at this year's innovation which will permit a visit to the Bureau of Standards, a department of the government which in a few years has greatly gained in importance and influence, and with which our working relations have become closer as the Bureau has been given representation upon our important technical committees. The Bureau has a commodious audience room, equipped with a projection lantern and motion picture machine, and is thus well equipped to take care of our regular business session Wednesday morning, May 9th. After luncheon guides will conduct members on tours of the laboratories, and Director Stratton has planned some interesting tests for the afternoon, when we shall have no business session. Members may gather from the advance printed reports that this meeting will give us no time for play. The program committee had hoped to plan an afternoon visit to Mount Vernon, but the afternoon at the Bureau of Standards absorbs all the time that can possibly be spared from our daylight hours.

At the "round table" discussion on *Safeguarding Life in Theatres,* Thursday, May 10th, we shall have as our guests the members of the Building Officials' Conference, meeting in Washington on that day, the same group that united with us in New York in 1915 for our discussion of building regulations. The prospective "round table" on *Ammunition Factories and Storage and Transportation of Explosives,* which is planned for Tuesday, afternoon, May 8th, is given special emphasis as this issue of the *Quarterly* goes to press, by the frightful explosion of April 10th at the plant of the Eddystone Ammunition Corporation near Chester, Pa., in which over 120 employees, mostly women and girls, were sacrificed.

Asbury Park Conflagration. •The *Frontispiece* of this issue gives a view of four blocks of Asbury Park, N. J. after the fire of April 5. Forty-eight buildings, including the First Methodist Episcopal Church and the Winthrop Hotel and Evonport Inn, two of the largest hotels, were destroyed. The other structures burned were small boarding houses and cottages.

It was in the Natatorium, a swimming pool owned by the city and located on the board walk between First and Second Avenues, that the fire started.

Fanned by a sixty-five-mile an hour gale, the fire swept everything, before it, raging so fiercely for hours that thousands of Easter visitors at the big hotels, many squares away, remained up all night.

While the fire was still burning, the mayor and the other members of the City commission held an emergency meeting and voted to rebuild the Natatorium, calling for bids not later than April 16. Other property owners who suffered by the fire have also announced their intention of rebuilding, the prevailing idea being to get the work started at once so that every part of the resort will be ready for the annual summer rush and none of the revenue harvested from the pleasure-seekers shall be lost. This haste with this object promises little improvement over the building construction that lent itself so readily to this month's sweeping fire. The City commission would do better to forego some of this summer's nickels and build something besides tinder boxes. The Asbury Park conflagration was more of a disgrace than a misfortune. No other lesson can be derived from it.

* * * * *

Free Water for Fire Protection. Pittsburg in spite of her mayor's opposition has followed the example of Chicago in providing free water for automatic sprinkler systems.

Some years ago a general ordinance was adopted providing that all water connections should be equipped with meters and under this ordinance the city water department recently undertook to force the installation of meters to sprinkler service lines. Opposition at once developed on the part of citizens who understood the objections to this procedure.

A movement was started to provide for the exemption of automatic sprinkler systems and such an ordinance was introduced in Council and passed by a vote of 7 to 2 and went to the Mayor for approval. The Mayor promptly vetoed it stating that he did so in the interest of the conservation of the water supply and in line with the general principle of metering all service lines. The Council then repassed it by the necessary majority over the Mayor's veto.

* * * * *

School-house Fire In Philadelphia. Inquiry respecting the newspaper report of a recent fire in the Hanna Public School, 58th and Media Streets, Philadelphia, elicited the following information from our member, Fire Marshal George W. Elliott:—

From our investigation it was apparent that the fire had its origin beneath a stone stairway leading from the basement to the first floor under which were stored

janitors' clothes and utensils including oils and rags, and from what knowledge could be gained after the fire, since no one was in the immediate vicinity when the fire broke out, it seems fair to conclude that combustion of spontaneous nature originated from the oily rags used for cleaning purposes. The stairway was of stone, but the door leading from the closet arrangement under the stairway into the basement was of wood, and since the latter was burnt and not blown off, the Assistant Fire Marshal concluded there was no explosion, as had at first been stated. The Superintendent of Janitors agreed subsequent to the fire to carry out an order of this office and remove all such closet places under stairways in the public school buildings of Philadelphia.

Philadelphia has done well to rid her schools of this dangerous and unnecessary hazard, and perhaps for achieving this result, the fire in the Hanna School was not too great a price.

* * * * *

Underwriters' Laboratories' New Electrical Council. Our member Underwriters' Laboratories has made a new and interesting departure in the appointment of an Electrical Council to supervise the work of its Electrical Department. This work has heretofore been covered by the Fire Council of the Laboratories, but the work has grown so in volume and importance that it has been judged necessary to appoint a special Council for this branch. The personnel comprises many well-known electrical engineers in charge of municipal and underwriters' electrical inspection departments in the United States and Canada, most of whom are associate members of the N. F. P. A. The initial meeting of the Electrical Council was held at the Machinery Club, New York City, on March 28.

* * * * *

Painted Curbs as Warning Signals. By ordinance many cities specify that vehicles may not stand within a certain distance of a fire hydrant. In San Bernardino, Cal., it is 15 feet, and as a reminder the fire chief has had the hydrant curb painted red. In addition in white letters are stenciled the words "Keep Away." In some of the outlying districts of Chicago the curb opposite catchbasins has been painted red, presumably for the purpose of quick location should the sewer clog and flood a large area of the adjacent pavement. Following a heavy snowfall the location will be facilitated, as gutter plows will uncover the curb.

Courtesy of Sandusky Cement Co.

Terraced gardens of G. W. Wattles, Hollywood, California

The above photograph illustrates the possibilities of cement-concrete for decorative service both in a small way, for flower pots, garden seats, pedestals, stands, urns, etc., and for what may rightly be termed gigantic landscape plans. This garden is terraced upwards from the house. A vast gash was excavated in the hill back of the house in order to make possible the work, but the disfigurement of the landscape occasioned thereby was entirely rectified by the system of walls, steps and terraces constructed of cement and by the planting.

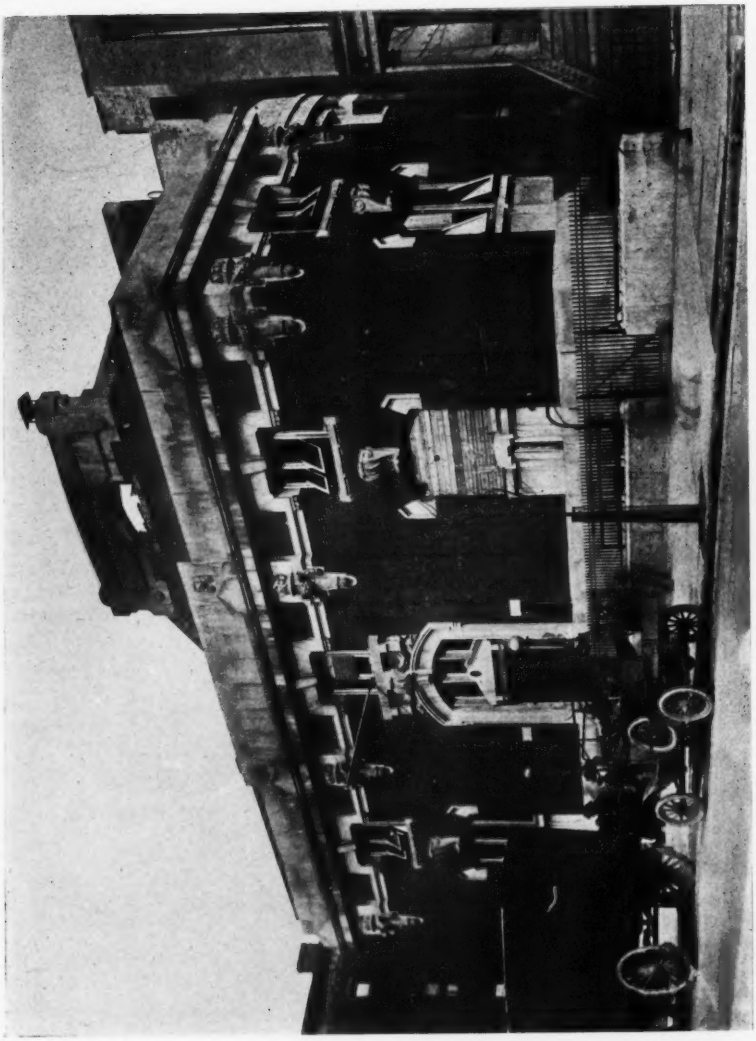
The Wooden Shingle Called a Menace to Apple Pie

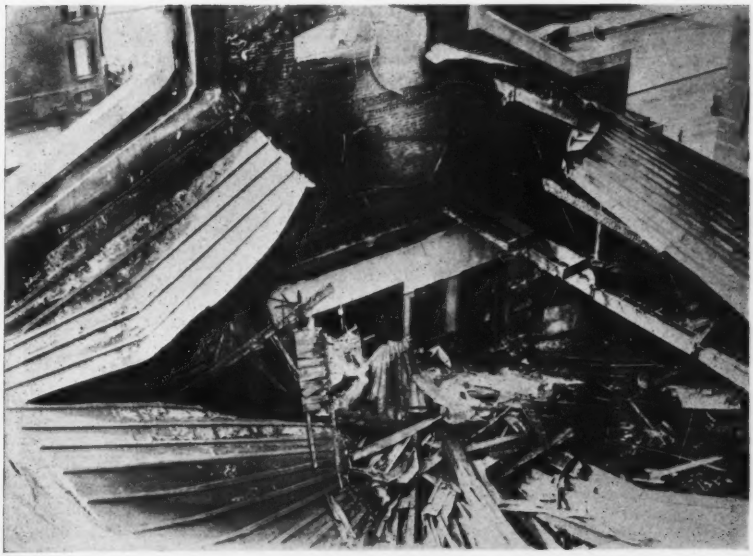
Editorial, American Lumberman, Feby. 24, 1917.

Lumber and lumbermen have been blamed for so many things, from fires in concrete buildings to climatic changes in Maine and Michigan, that it will be merely interesting for them to learn now that the tree from which they cut the shingles that cover the roofs of a large proportion of American homes is responsible for frequent failure of the apple crop in some sections of the country. According to *Farm and Fireside,* the apple rust is a disease caught by apple trees from red cedar trees. "There is no doubt about the matter," says the editor of *Farm and Fireside;* "the source of the infection has been conclusively shown time and again."

However, this suggests an interesting idea for the lumbermen's friend, Franklin H. Wentworth, the enterprising secretary of the National Fire Protection Association. When his anti-wood shingle propaganda in the public schools, daily newspapers, insurance offices and elsewhere fails of its purpose of creating a market for substitute roofing materials that do not seem able to sell on their own merits in open competition with wood shingles, let him make his appeal to the famous American appetite for apple pie and apple dumplings. He ought to be able to start something if he can convince the public that a red cedar shingle roof means that all the apple trees for miles around curl up their roots and die. Anyway, there would be about as much practical common sense in this sort of publicity campaign as in the reiterated but unproved charge that wood shingles are responsible for most large conflagrations and for a large share of the great national fire loss.

The above is typical of the character of the weekly editorials appearing in the *American Lumberman* for the past year or so.





Public Library Built to Burn.

Two fires of suspicious origin recently occurred in the right and left wings of the Pacific Branch of the Brooklyn Public Library, which occupies the two-story brick building at Nos. 27-33 Fourth Avenue, Brooklyn.

The blaze in the right wing burned itself out, but the other fire had gained considerable headway before it was noticed. The interior decorations were destroyed and several thousand books consumed or ruined by smoke and water. The damage is estimated at from $30,000 to $50,000.

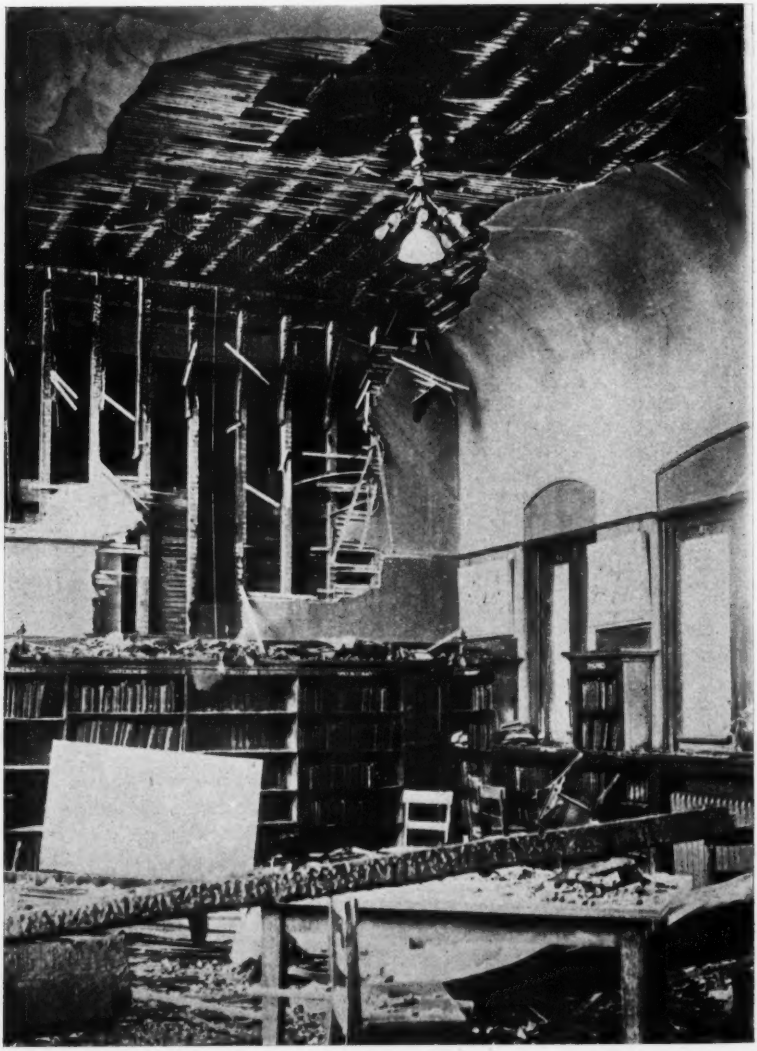
The fire was discovered by a policeman who saw dense smoke pouring from the cupola. After turning in an alarm, the officer tried to get into the building, but could not. The firemen had to break their way in when they arrived.

The blaze was confined to the left wing, and it was not until some time later that the discovery was made that a second fire had been burning under some ladders in the right wing, but had failed to spread.

Tarpaulins were stretched in the hope of being able to save some of the books in the burning portion of the building, and thirty firemen on the main floor had a narrow escape when three balconies collapsed simultaneously. The blaze was under control after two hours' work.

More interesting, however, to our members than the details of the fire will be the accompanying photographs for which we are indebted to the courtesy of Mr. F. J. T. Stewart. In Mr. Stewart's own words they "show how a public library should not be con-

structed." Large spaces between partitions were used as ducts for pipes, vents, etc., and formed a flue of liberal size directly connecting the cellar with a large combustible attic. The result was that when the fire occurred in the cellar it immediately communicated to the attic causing the roof to collapse, and involving heavy damage to the entire building with the exception of the masonry walls.



Safe and Unsafe Uses of Wood in Buildings.*

By Sidney J. Williams

(Member N. F. P. A.)

Building Inspector, State of Wisconsin.

A few years ago one would have hesitated to address a meeting of lumber manufacturers and dealers on the subject "Safe and Unsafe Uses of Wood." A few years ago the lumberman believed as a matter of course that wood was the perfect material for every purpose, and looked with bitter contempt on any effort to restrict or regulate its use. Now you have met here, representing every department of the lumber industry, to discuss frankly, and in a spirit of scientific inquiry, the qualities and uses of different woods as compared with one another and with other building materials. It is a thing of which you may well be proud, that through all these discussions the thought is expressed or implied that good salesmanship does not consist of bluster and brag, but rests upon an accurate knowledge of one's material, including its limitations as well as its advantages.

Safety is one important characteristic of any building material. Other important characteristics are cost, appearance and workability. No material or method of construction can base a valid claim to recognition on safety alone, or on cheapness alone. The pioneer farmer on the western prairies built himself a dugout in the side of a hill and roofed it with turf, thereby securing a dwelling which was certainly cheap, but sadly deficient in durability, comfort and appearance. The Egyptian pyramids, built by the labor of thousands of slaves extending through many decades, are a fine example of durable construction, but do not commend themselves to the modern builder who must consider time and money.

In any given case the efficient designer or builder must choose his material not with reference to cheapness alone or safety alone or any other one characteristic. He must consider all of these elements in their relation to one another and to the purpose for which the building is intended.

In the exercise of judgment on these questions, many sincere differences of opinion will be found, even among experts. Certain principles can, however, be clearly established.

The Roman Pantheon and some of the Roman aqueducts still stand and still serve the same purpose for which they were built two thousand years ago. All over Europe the cathedral builders of the middle ages have left examples of the architects' and builders' art which have retained their original usefulness and their original beauty for centuries, and will retain them for centuries more unless

* Address at Northern Lumbermen's Salesmanship Conference arranged by Northern Hemlock and Hardwood Manufacturers' Association.

they are blown to pieces by forty-two centimeter shells. As long as man worships he will require temples, and as long as he craves the beautiful and the sublime in architecture he will be glad that the master builders of long ago used the most permanent materials at their command. Likewise it is entirely fitting that the designers of our new capitol at Madison, or of any other monumental public building, should follow the example of the cathedral builders so that the inspiration of their work may endure for many generations.

In other structures of more modern type, resistance to the elements is likewise essential. We do not know how long the twenty-story office building will be suffered to stand; but even if its life should be a short one, the protection of its large population and of the surrounding property requires the highest type of fire-resisting construction. In a large school or theatre also, the possibility of fire involves such serious consequences to the occupants that it must be reduced to a minimum.

These classes of buildings are, however, but a small fraction of the total. There are other classes far more numerous, where initial cost is the controlling factor, where fire resistance is less important, and where durability is sometimes a defect. Under this heading come practically all private dwellings, excepting those of the wealthy, small stores, factories, and other business buildings, including more than 90 per cent. of all buildings in a small growing community, and certainly more than 50 per cent. even in a large city. Our cities are growing and will continue to grow, and most of the structures which we are erecting today will outlive their usefulness and will be torn down to make room for larger and better structures. Since these buildings are not intended or desired to be permanent, and since their contents are not of very great value, it is not quite so important that they be made fireproof. I do not mean that we should build them to burn; I mean that the possibility of their burning is simply one economic factor to be considered in connection with their first cost and their cost of maintenance.

This whole point of view is well summarized in the wording of the statute under which our State Building Code is administered. The statute says that all buildings must be "reasonably" safe, meaning that they must have such a degree of safety against fire and other hazards as is compatible with their location, size and occupancy. Such reasonable safety is all that should be required by the laws of any state or city, and is all that the most ardent fire protectionist should ask or desire. Such reasonable safety, I am sure, is also the aim of every manufacturer or dealer in lumber or any other building material who sees clearly his own ultimate self-interest.

These considerations apply particularly to the cheaper sort of dwellings. Here a low first cost is essential; and so long as our supply of lumber holds out, dwellings will continue to be built mostly of wood. Before discussing the fire protection of such a building let us refer briefly to another element of safety, namely, the strength of lumber and its resistance to deterioration and collapse. You are advertising hemlock as "Old Faithful." The opinion prevails among building contractors that a hemlock plank, when exposed to sun

and rain, will warp and check and may finally break without warning under a sudden load. For this reason many experienced contractors refuse to use hemlock for scaffold lumber, by which I mean lumber used only for scaffold purposes and therefore exposed continually to the elements. This fact is supported by a book on scaffolding published by the Travelers Insurance Company and based upon their experience, in which it is stated that hemlock should not be used for scaffolding.

If this unfortunate reputation of hemlock is due to poor grading, let us hope that steps have been or will be taken to remedy the defect. If it cannot be remedied, and if hemlock is in fact unsuited for use where exposed to alternate rain and sun, then the self-interest of the lumber industry, as well as public safety, requires that the wood be not recommended or sold for that purpose. This of course does not refer to the small carpenter job where planks are used as scaffolding for a few days and then worked into the permanent structure.

In locations not exposed to the elements I have no reason to doubt that the epithet "Old Faithful" is correctly applied to hemlock. It is true, however, that for use as studding or joists which are under a continual strain, there is a prejudice against hemlock in the minds of many architects and engineers. This prejudice is largely due to loose methods of grading heretofore used. The best way to overcome it is to adopt and enforce rigid grading standards uniformly throughout Wisconsin and adjacent states, so that when an architect or engineer specifies number one or number two hemlock, he may know exactly what he will get. A program of strict grading will be quickly appreciated by all designers. Architects and engineers should be supplied with copies of the grading rules, showing the actual sizes of all dimension lumber, together with suggestions as to the proper uses of the different grades, and tables of safe loads and stresses based upon the recommendations of the United States Forest Service. Such information prepared under the technical guidance of your secretary and engineer will prove the best possible advertising.

Returning now to the fire hazard in wooden buildings, let us first note that the combustibility of the building material is only one item in the list of fire hazards. If we could prevent all fires from starting, it would make no difference whether our buildings were made of concrete or wood or celluloid. We cannot quite prevent all fires; but experience in individual plants and in whole communities has proven beyond any question that we can prevent a large majority of them. One important cause of fires is the defective chimney. A building law of the eighteenth century prohibits the construction of wooden chimneys. We do not build that kind of chimney nowadays, but we do often build a brick chimney without flue lining, resting on a wooden bracket, and with wooden joists built into the brickwork. This sort of construction has caused thousands of fires, especially in dwellings of frame construction. Other frequent causes, well known but often disregarded, are furnaces or smoke pipes close to woodwork; defective electric wiring or gas piping; spontaneous

ignition of oily or painty rags; careless handling of gasoline, and many others too numerous to mention.

I suggest in all seriousness that this association join hands with other agencies of fire prevention in seeking the education of itself and the general public on these hazards of carelessness. If half of all fires can be eliminated, then half of the argument against combustible construction will fall. When we again celebrate Fire Prevention Day on the ninth of next October, I hope that all of you will take an active part by displaying posters and joining in the public exercises.

Those fires which we cannot prevent should be checked before they become serious, by introducing fire stops at strategic points. You are all familiar with standard mill construction, which is recognized as next in fire resistance to concrete, steel and tile. In mill construction no concealed air spaces are permitted, through which fire may travel; all elevator and stair wells are enclosed, and large areas are divided by fire walls. In this way the rapid spread of fire is prevented.

It is not generally known that these same principles can be economically applied to buildings of moderate cost and of frame or ordinary construction. The National Board of Fire Underwriters has recently issued an exceedingly interesting and valuable pamphlet on the subject of fire protection in dwellings. This pamphlet describes in detail the sort of fire stops which may economically be provided in a small dwelling and which will eliminate the greater part of the fire hazard associated with wood construction. In the ordinary dwelling the stud partitions form a series of vertical flues through which fire can spread rapidly from cellar to garret. These partition spaces connect with the spaces between joists, which in turn run from side to side of the building and connect with other vertical spaces in the other partitions and in the outside walls. Under these conditions it is not strange that a dwelling house, once afire, generally either burns to the ground or requires so much water for extinguishing that the damage is almost total. It is also not strange that in dwellings of this construction a fire starting at night often spreads so rapidly as to cut off the escape of the occupants. The bulletin which I have mentioned shows how this hazard may be practically eliminated by simply fire-stopping the spaces between the studs and joists at each floor level with a small quantity of brick and mortar, concrete, mineral wool, or similar material, or even by fire stops of 2-inch lumber tightly fitted in between the studs. The wooden fire stop, if properly installed, is sufficient, because if the draft is cut off the fire cannot spread. The only danger is that the carpenter will put in loosely fitting boards which do not cut off the draft and therefore do not stop the fire. Mortar or concrete which fills all the cracks makes a better fire stop on this account.

I suggest that these methods of fire protection for dwellings and other small buildings be widely advertised by this organization. If you can show your clients and customers how to eliminate this important hazard, you will have the best possible answer to statements regarding the inflammability of wood construction.

We have already referred to the type of building known as standard mill, in which we have mentioned the precautions taken to prevent the rapid spread of fire. A building which complies with standard mill specifications and is equipped with an automatic sprinkler system, ordinarily obtains a lower insurance rate than a building of strictly fireproof construction without sprinklers. The smallest joist used in mill construction is 6 x 12 or 8 x 10, and the thinnest flooring, excepting the hardwood finish floor, is 3-inch plank. As there is not much material of this size left in Wisconsin, mill construction is probably not so interesting to this audience as it would be in the south or west. The principles underlying mill construction are, however, always interesting because they show what real fire-resisting construction is. According to Edward Atkinson, practically the originator of this type of building, mill construction consists,—

1. "In so disposing the timber and plank in heavy solid masses as to expose the least number of corners or ignitable projections to fire, to the end also that when fire occurs it may be most readily reached by water from sprinklers or hose.

2. "It consists in separating every floor from every other floor by incumbustible stops — by automatic hatchways, by encasing stairways either in brick or other incombustible partitions — so that a fire shall be retarded in passing from floor to floor.

3. "It consists in guarding the ceilings over all specially hazardous stock or processes with fire-retardant material such as plastering laid on wire lath or expanded metal or upon wooden dove-tailed lath, following the lines of the ceiling and of the timbers without any interspaces between the plastering and the wood; or else in protecting ceilings over hazardous places with asbestos air cell board, sheet metal, Sackett wall board or other fire-retardant.

4. "It consists not only in so constructing the mill, workshop or warehouse that fire shall pass as slowly as possible from one part of the building to another, but also in providing all suitable safeguards against fire."

Mr. Atkinson further describes "What Mill Construction is not," as follows:

1. "Mill construction does not consist in disposing a given quantity of materials so that the whole interior of a building becomes a series of wooden cells; being pervaded with concealed spaces, either directly connected with each other or by cracks through which fire may freely pass where it cannot be reached by water.

2. "It does not consist in an open-timber construction of floor and roof, of light and insufficient size in timbers and thin planks, without fire stops or fire guards from floor to floor.

3. "It does not consist in connecting floor with floor by combustible wooden stairways encased in wood less than two inches thick.

4. "It does not consist in putting in very numerous divisions or partitions of light wood.

5. "It does not consist in sheathing brick walls with wood, especially when the wood is set off from the wall by furring.

6. "It does not consist in permitting the use of varnish upon woodwork over which a fire will pass rapidly.

7. "It does not consist in leaving windows exposed to adjacent buildings unguarded by fire-shutters or wired glass.

8. "It is dangerous to paint, varnish, fill or encase heavy timbers and thick plank as they are customarily delivered, lest what is called dry rot should be caused for lack of ventilation or opportunity to season.

9. "It does not consist in leaving even the best-constructed building in which dangerous occupations are followed without automatic sprinklers, and without a complete and adequate equipment of pumps, pipes and hydrants.

10. "It does not consist in using any more wood in finishing the building after the floors and roof are laid than is absolutely necessary."

Even where we are unable to provide the heavy floors and timbers called for by these specifications, we can approach in many ways to the mill construction idea by eliminating or fire-stopping concealed air spaces, enclosing stairways, omitting light wooden partitions, protecting exposed windows with metal frames and wired glass and providing proper fire extinguishing equipment,—all of which can easily be done at moderate cost.

There is one other fire hazard in wooden construction on which you may not be persuaded to agree with me. I refer to the wooden shingle, which has been the cause of so much violent controversy. The wooden shingle has been assailed as a dangerous fire hazard, because fire brands carried by the wind often ignite shingle roofs three or four blocks from the original fire, especially if the shingles are old and their edges curled up. In this way a conflagration often spreads with such rapidity, jumping several blocks at a time, that the fire department is unable to cope with it. This has actually occurred in almost all disastrous conflagrations. I therefore cannot avoid stating the frank opinion, based on a considerable study of the subject, that in any community where houses are built less than a hundred feet apart, the wooden shingle does introduce a considerable conflagration hazard; and further that this fact is being and will be recognized to such an extent that the abolition of the unprotected wooden shingle in such communities is only a question of time.

Please note that I say the "unprotected" wooden shingle. Here is the saving element in the situation, which furnishes an opportunity for harmonious action by the lumber interests on the one hand and the friends of fire protection on the other. For a long time chemists and inventors have been working on the development of solutions which will satisfactorily fireproof wood. In New York City for many years such "fireproof wood" has been required for trim in buildings over a certain height. Recently, much study has been given to the perfection of a stain or paint which can be applied to wood shingles to increase their fire resistance. Many building officials and architects have a high regard for some of these preparations now on the market. If a substance has been, or can be, found, which will increase the life of the shingle as well as its fire resistance, and incidentally give it whatever color may be desired, then surely the problem will have been solved.

I have thus tried to outline the field which lies open to the lumber industry without any transgression upon reasonable public safety. This field is a large one, and gives free rein to all the ingenuity and energy and money that you have to devote to promotion and sales. With this field open to you, it will be no hardship to keep away from the few classes of buildings which in my opinion should be reserved for the less combustible and more expensive materials.

There are, unfortunately, in your industry, some who are unwilling to accept any limitation at all. A city on the Pacific coast recently built a large three-story school building, which is said to contain more lumber than any other building in town. This fact was prominently advertised on a large billboard placed before the building. The men who authorized this building and the men who ad-

vertised that it contained more lumber than any other building in the city, were either totally ignorant or totally reckless of the safety of the hundreds of school children who were to occupy it. Pictures of this school and the billboard in front of it have gone from the Pacific to the Atlantic and have been the worst possible advertisement for the lumber industry. I am very glad to say that this sort of mistaken enthusiasm for lumber is entirely foreign to the spirit of scientific candor which permeates the work of the Wisconsin association under its present leadership.

As long as you keep this spirit, the department which I represent, and I believe all state departments, are with you in your work of developing one of the state's most important industries. In particular my department believes that Wisconsin hemlock, properly graded, and limited to the loads and stresses recommended by the Forest Service, is a safe and suitable material for studding, joists and other common uses, in any building where lumber may safely be used.

I trust that your association will long continue its present policy of promotion, based on the scientific study of your material, and the circulation of accurate and reliable information relating thereto. In this way you will best serve both the public and yourselves.

Laying sections of 15-inch concrete floor slabs 51 x 41 feet beteen joints.

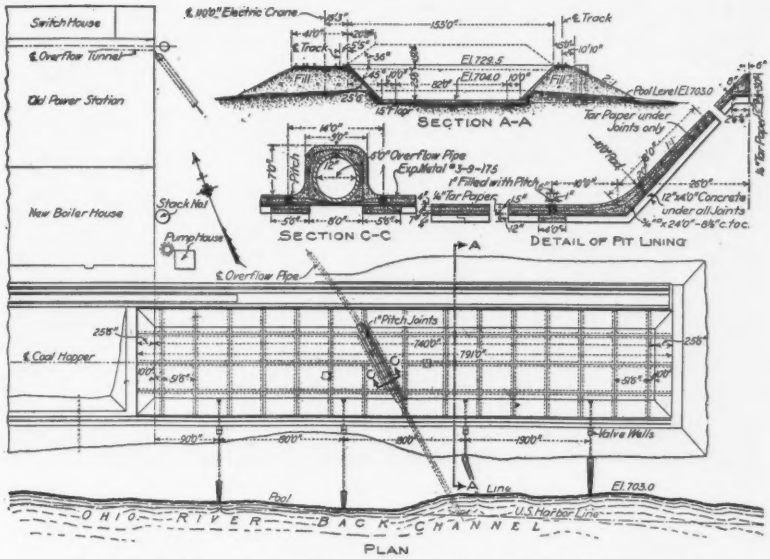
Storage of Coal by Submersion.

Courtesy of Engineering Record.

A huge pit, 150 feet by 800 feet in plan and 25 feet 6 inches deep, with 45-degree side slopes, will provide the Duquesne Light Company of Pittsburgh with safe storage space for a 100,000-ton pile of coal. The danger of spontaneous combustion will be prevented by submerging the coal in water up to the top of the pit, which is located near the Company's main generating plant on Brunot's Island. The concrete lining was laid in blocks about 40 feet by 50 feet in size, separated by construction or expansion joints waterproofed by pitch and tar paper above a 12-inch base of concrete 4 feet wide. In lining the side slopes, traveling structural steel frames were used to support the unit timber forms. Another special feature was the method of overcoming difficulty in keeping the 1-inch expansion joints clear while concreting slabs by adopting thin steel plates held in place by iron pins and clamps.

Design of Pit and Concrete Lining.

As illustrated by the accompanying plan and sections, the top of the reservoir is 153 feet wide and 791 feet long, and the depth is 25 feet 6 inches, so that with a surcharge of 15 feet the capacity is about 100,000 tons of coal. The floor is paved with concrete 15 inches thick reinforced by two layers of expanded metal. The 45-degree side slopes on the inside of the embankment forming the sides are paved with concrete reinforced by expanded metal and cast monolithically with a bottom section 10 feet wide, using curved reinforcing rods at the intersection, as shown in the detail drawing. The thickness of the side slopes varies uniformly from 20 inches at the bottom



Plan and sections of huge coal storage reservoir—Details of waterproofed expansion joints.

to 8 inches at the top. The outer slopes of the embankments are protected by riprap built up of one-man stone.

Water for submerging the coal is pumped into the reservoir through a 14-inch cast-iron pipe line leading from the power house to four 12-inch cast-iron outlet pipes placed 160 feet apart in plan and about 6 feet below the top of the reservoir. The 6-foot concrete overflow pipe shown on the plan is in no way connected with the water system of the new reservoir, but was already in place when construction was commenced. The special covering of reinforced concrete shown on the drawing was designed to protect it from injury.

In order to prevent upheaval of the floor by uplift pressure if the pit were empty during flood conditions in the river near by, the drainage system, consisting of four 18-inch pipe lines located as shown on the plan, is equipped with check valves. These valves permit the water to rise inside the pit as the river rises in times of flood. The normal water elevation is at the level of the 15-inch concrete floor of the pit.

Details of the special expansion joints are indicated on the drawing. These joints are placed about 51 feet apart longitudinally and extend entirely across the base and sides with three longitudinal joints 41 feet apart, as shown in the plan. Some difficulty was experienced in keeping clear the 1-inch open joints which receive the soft pitch between the concrete sections. The scheme finally adopted, which proved satisfactory, was to place 18 by ⅛-inch steel plates

Concrete for sloped sides placed by use of steel traveling forms.

6 feet long in vertical position along the curbs of the previously constructed sections and hold them in place by clamps over the top of the curbs, spacing them, to give the required 1-inch opening, by the use of round iron hook pins on 12-inch centers. These pins were easily removed after the floor slab had been cast. The steel plates, well oiled before placing, were then quickly taken out for use in a new joint.

Excavation made in two longitudinal cuts by drag-line excavator.

The excavation for the pit was made by a Bucyrus drag-line excavator running two longitudinal cuts, the greatest depth of cut being 25 feet. At the east end embankments were required. The material for these was obtained by moving the excavated earth from the west end in 4-yard dump cars.

A central concrete plant located on the river bank adjacent to the work was used to supply concrete for the pit and also for the construction of two large intake wells being built at the same time about 100 yards away. Gravel and sand for the concrete were obtained in barges along the river and were hoisted directly into a bin with a capacity of about 150 yards which fed a ½-yard Haines mixer, from which the concrete was elevated by a tower and a part placed directly in position by a system of chutes. The remainder of the concrete was loaded into specially designed side-discharge cars and transported to points from which, by means of chutes, it could be placed in position.

Special Steel Traveling Form Employed.

It was found necessary in order to retain the concrete on the 1 to 1 slope to use a special steel traveling form consisting of six trusses resting on rollers and traveling on single rails, one at the top and one at the bottom of the slope. The face forms proper were made of wood in removable panels about 3 feet by 10 feet in size and were attached to angles by lugs, the angles being suspended from the trusses by rods fitted with turnbuckles to allow adjustment to proper alignment.

Water Hammer Ruptures Centrifugal Pump.

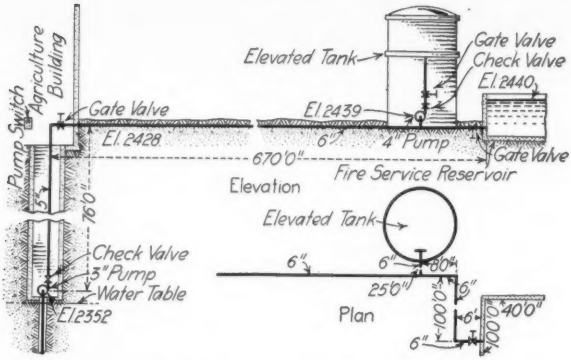
By A. L. Enger, Tucson, Arizona

(Courtesy of Engineering Record)

Water hammer, resulting from a sudden shutting off of power from a well pump at the University of Arizona, broke the shell of another centrifugal pump employed as a booster to supply an elevated tank. To prevent the recurrence of such an accident a check valve has been placed in the pipe line near the fire-service reservoir into which the well pump discharged.

The sketch shows the system of piping from the well to the elevated tank and the new fire-service reservoir. The two pumps shown are single-stage centrifugal pumps direct-connected to induction motors.

The pump in the well has a 3-inch discharge and furnishes 415 gallons per minute when pumping into the fire-service reservoir. The pump under the tank is a 4-inch pump and is used for boosting the water from the 3-inch pump into the elevated tank. Ordinarily, the 3-inch centrifugal pump discharges into the fire-service reservoir,

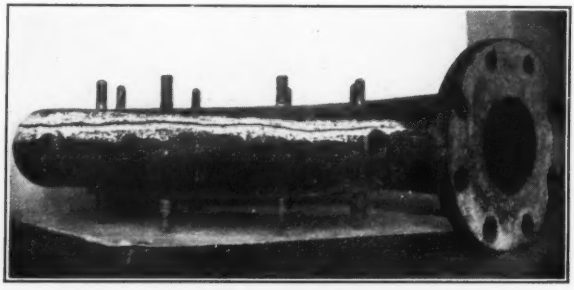


Arrangement of piping, reservoir and pumps at University of Arizona Grounds.

from which the water overflows into the irrigation system watering the campus.

Water Hammer When Pump Stopped.

When the well pump was first installed, the violent water hammer caused by suddenly stopping the pump when discharging its normal capacity was observed, and a rule was therefore made that the gate valve in the discharge line at the top of the well should be closed—stopping the flow from the pump—before the pump was stopped. One day, through a misunderstanding, the main switch on the power line to the campus was pulled out while the well pump was discharging into the fire-service reservoir, and the resulting water hammer broke the case of the 4-inch pump under the elevated tank. The crack shown in the photograph is on the suction side of the case and extended about three-fourths of the way around the pump. The gate valve just over the 4-inch pump was closed at the time of the accident.



How water hammer cracked casing of centrifugal pump.

One explanation of this accident is as follows: It is assumed that the water in the vertical section of the discharge pipe in the well stopped rising almost immediately after the power was shut off, and settled down on the check valve. The water in the horizontal pipe, flowing with a velocity of about 4. 7 feet per second at the instant the power was shut off, would not stop immediately, but would continue forward for a short time, due to its inertia, causing the column of water to separate near the top of the well. The pressure of the water in the reservoir then forced the water in the horizontal pipe back, and at the impact between the two columns of water a pressure wave was generated which traveled through the pipe line and broke the case of the 4-inch pump.

Roof Coverings and Their Fire Resisting Properties.

PART I.

Introductory

By W. T. Colyer
(Member N. F. P. A.)

No longer has the propagandist of fire prevention to persuade his fellows of the unique qualities of the wooden shingle as a conflagration breeder. The relentless logic of events has convinced most people of ordinary intelligence that wind-borne brands from already burning wooden roofs not only *may be*, but constantly *are*, the means of facilitating city conflagrations. The controversy now centers around the question: What shall we do about it?

State Legislatures and municipal authorities all over the country are wrestling with the problem of drafting laws and ordinances which, without subjecting any individual to an intolerable economic burden, shall result in gradual replacement of wooden roofs by less hazardous coverings. Even state-wide prohibition of the wooden shingle has been mooted in Texas; and the number of cities which require fire-resistive roofing, at least within their fire limits, is steadily increasing. In some cases the whole of the city is covered by such an ordinance. Hopeful movements are on foot in Kansas City, Mo., and Rochester, N. Y., with a view to including those two important centers of population in the list of cities absolutely barring the wooden shingle. In Rochester the campaign is being waged by that indefatigable friend of fire prevention, the Rochester Chamber of Commerce; while in Kansas City the revelation that during the past winter there have been on an average nearly five fires per day attributable to sparks upon wooden shingle roofs in the city, has greatly stimulated the efforts of those who are working for the enactment of prohibitory clauses in the new building code. The growing use of bituminous coal in the Middle West is a factor in increasing the number of fires of this sort.

In the important article dealing in detail with the fire-resistive properties of various roof coverings, to which the present observations are merely a preface, Underwriters' Laboratories do not, for obvious reasons, concern themselves with questions of relative cost, nor with the objections which the plain citizen is likely to encounter when he begins to interest himself in the problem of the fire-resistive roof. It is appropriate, therefore, that a few words should be said on the general question by way of introduction to the main article.

The precise significance of the Laboratories' classifications, for instance, may easily be misrepresented to the plain man. Opponents of all reform often make the point that it would be impracticable to

secure the universal adoption of roof coverings approved by the Laboratories under Classifications A or B, and that it is hardly worth while putting oneself to any trouble to substitute a "Class C" product for the "evil wooden shingle," particularly as the latter can be treated with fire-retardant paints which will reduce its liability to ignite from flying brands. In point of fact it is open to grave doubt whether the wooden shingle can be effectively protected by fire-retardant paint without such an increase of cost as would render wooden roofing uneconomical when compared with other types possessing materially greater fire-resistive properties. However that may be, the fact remains that no treated wooden roofing has up to the present time succeeded in satisfying the tests required as a condition of approval by the Laboratories; and even should such a roofing be feasible, it would still in all human probability retain the characteristic of communicating fire by means of brands whenever it ignited from a fire in the structure beneath. The great gulf is fixed not between Classes A and B, or between Classes B and C, but between approved and unapproved roofings. It is, of course, true that asphalt shingles may be ignited when flame is experimentally applied to their edges, but so also may the wooden shingle. The superiority of the former especially appears when they are in position on the roof, where they resist ignition from sparks or brands. The language of science is always chilly when compared with that of (say) political partisanship or salesmanship; and the standards of science are rigid and exacting. It therefore behooves the plain man to remember that the guarded approvals of Underwriters' Laboratories are written in scientific language without any desire to advertise the good qualities of any particular device or material. It is a safe rule to assume that if a product secures approval in any class from Underwriters' Laboratories, it will be a great improvement upon products which fail to secure approval.

Through the courtesy of a member who has exceptional facilities for making enquiries, we have obtained a number of up-to-date quotations of average prices of wooden and fire-resistive roofings in different cities. In all cases the prices quoted represent the "laid cost" per square of 100 feet.

In New York, wooden shingles were quoted at the rate of $8.50 and up: individual asphalt shingles at $9; asphalt strip shingles at $7.50; asbestos shingles (French method) at $14 to $15; and sheet tin roofing at $10.

In Chicago the figures were: wooden shingles, $5.70; individual asphalt shingles, $7.50; asphalt strip shingles, $6.50; asbestos shingles (French method), $12; slate, $12; tin shingles, $11.55.

In Boston, $9 per square was the quoted price for wooden shingles, and the same for individual asphalt shingles, asbestos shingles (French method) ranging from $14 to $15; tin shingles being quoted at $10.

In New Orleans the prices quoted were: wooden shingles, $6; individual asphalt shingles, $7; asbestos shingles (French method), $12; slate $9 to $10; tin shingles $7 painted, and $8.25 galvanized.

In Cincinnati, wooden shingles cost $6.50; individual asphalt shingles, $7.50; asbestos shingles (French method), $9; and sheet tin roofing $7.50.

The following quotations were obtained from Bridgeport, Conn.: wooden shingles, $8.50 to $9; individual asphalt shingles, $9; asphalt strip shingles, $8; asbestos (French method), $14 to $15; slate $12 to $15.

At South Bend, Ind., wooden shingles were quoted at $6 and individual asphalt shingles at $8.

These figures make it abundantly clear that there are types of fire-resistive roofing which can be substituted for the wooden shingle without causing economic hardship to property owners. It is understood also that the manufacture of asphalt roofing in twin, wide space, and strip shingles and in other forms is being developed, and that the effect of these modern inventions is progressively to reduce the cost of roofing by the saving of time and labor in laying. Many of the prepared roofings carry a ten-years' guarantee by the manufacturer, and are standardized by Laboratories' inspection, whereas a like guarantee in the case of wooden shingles is generally impracticable owing to the wide variations in the character of these.

Another point which is worth bearing in mind is that the cost of wooden shingles involves a much larger proportion for freight and labor in laying than do the other types of roofing. About 70% of all wooden shingles manufactured in the United States come from the Pacific Coast, and nearly 7% of the remainder are produced in the State of Louisiana. Both these regions are situated at a long distance from the great centers of population, and freight charges are correspondingly heavy. Factories for the manufacture of prepared roofing are springing up all over the country in close proximity to their markets, with a great resultant saving in freight costs, a part of which at least may be presumed to go into the improvement of the product. The same remark applies to the small savings on nails, etc., with the new types of roof, and to a larger extent to the saving of labor in laying as a result of the standardization and flexibility of many of the fire-resistive shingles.

As regards metal roofings, which are included in some of the above quotations, it may be observed that these vary greatly in the degree of resistance they offer to the spread of fire. A good tin-clad roof laid in accordance with the specifications of the Committee on Roofs and Roofings would undoubtedly afford a high degree of protection, but on the other hand there are types of metal roof, which while immune from the exposure hazard in the form of brands, are nevertheless open to the objection that they invite the use of exposed metal structural members, inasmuch as it is a common practice to wire roofing directly to trusses or other steel members which might, under severe exposure, expand sufficiently to cause a serious collapse.

For every type of fire-resistive roofing there is probably a logical place, but the settlement of that place is a matter for architects and contractors in the light of experience. Our contention is that there is no logical place in a prudent and well-ordered community for the perpetuation of the conflagration-breeding wooden shingle, unless it

can be shown that fire-resistive substitutes can only be obtained on prohibitive terms. The overwhelming weight of evidence is to the effect that there are substitute roofings available at a reasonable cost which will meet all structural requirements, afford reasonable protection against conflagrations, and at the same time satisfy the human demand for comfort and beauty.

PART II.

Methods of Testing Roof Coverings at Underwriters' Laboratories.

By George W. Riddle, Division Engineer, and **B. E. Blanchard,**
Assistant Secretary, Underwriters' Laboratories
(Members N. F. P. A.)

Roof coverings in general may be divided into two groups—the membrane type and the thatched type. The membrane type consists of a continuous water-proofing membrane, usually of sheets cemented together and coated with a water-proofing material, and the thatched type is made up of overlapping large or small sheets or slabs of water-proofing material laid in such a manner that the wash on the surface of the roof is over the edges of the sheets or slabs.

The fire-resisting properties of roof coverings of either type vary widely; depending upon the character, the form and the arrangement of the materials entering into the coverings, and upon the security of the fastenings. The value of roof coverings, from a fire protection viewpoint, depends upon the protection the roof coverings afford the roof decks against the transmission of heat and upon their ability to resist ignition and spread of fire over the surface as a result of exposure, upon their liability to slip from place as a result of exposure, upon the flying hazard possessed by the coverings, and upon the blanketing influence exerted by the coverings over fires within buildings on which they are applied. Roof coverings vary widely in their behavior under fire conditions and in their ability to resist exposure to fires, so that in passing judgment on the value of roof coverings as fire retardants all of the foregoing features must be taken into consideration.

To secure the best results, it is quite necessary to adopt standard methods of designing roof coverings which will develop all of the important factors, and which, at the same time, will establish a practical basis by which the coverings can be classified according to their fire-resisting properties.

During 1916 Underwriters' Laboratories prepared a standard which divides roof coverings according to their fire-resisting properties into three classes, and designed apparatus and installed equipment (Fig. 1), for conducting tests and classifying roof coverings of all kinds under this standard.

The methods adopted for testing roof coverings by the Laboratories include a careful study of the design and construction of

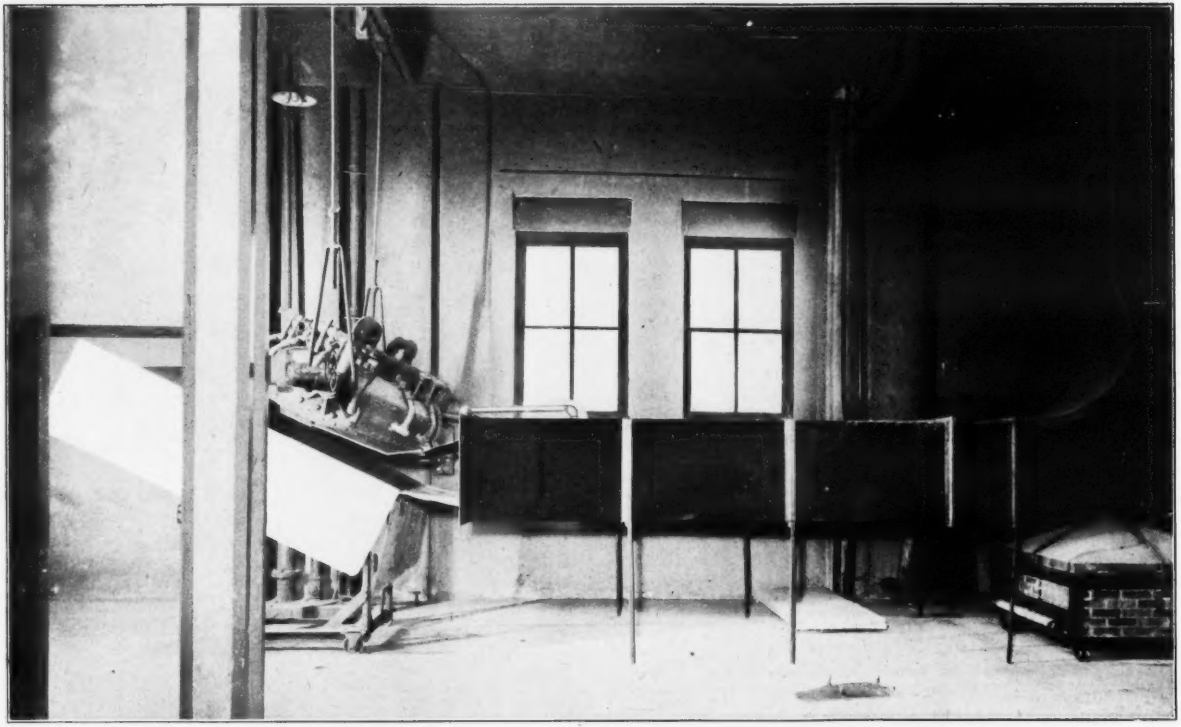


Fig. 1. Apparatus Used in Making Standard Fire Tests of Roof Coverings.

The cylindrical gas furnace is mounted on trunnions so it can be turned to any angle at which the roofing is tested. The air duct is of sheet metal and has a discharge opening 7 by 2½ feet. The air duct, motor and fan on the floor above are shown in Fig. 2.

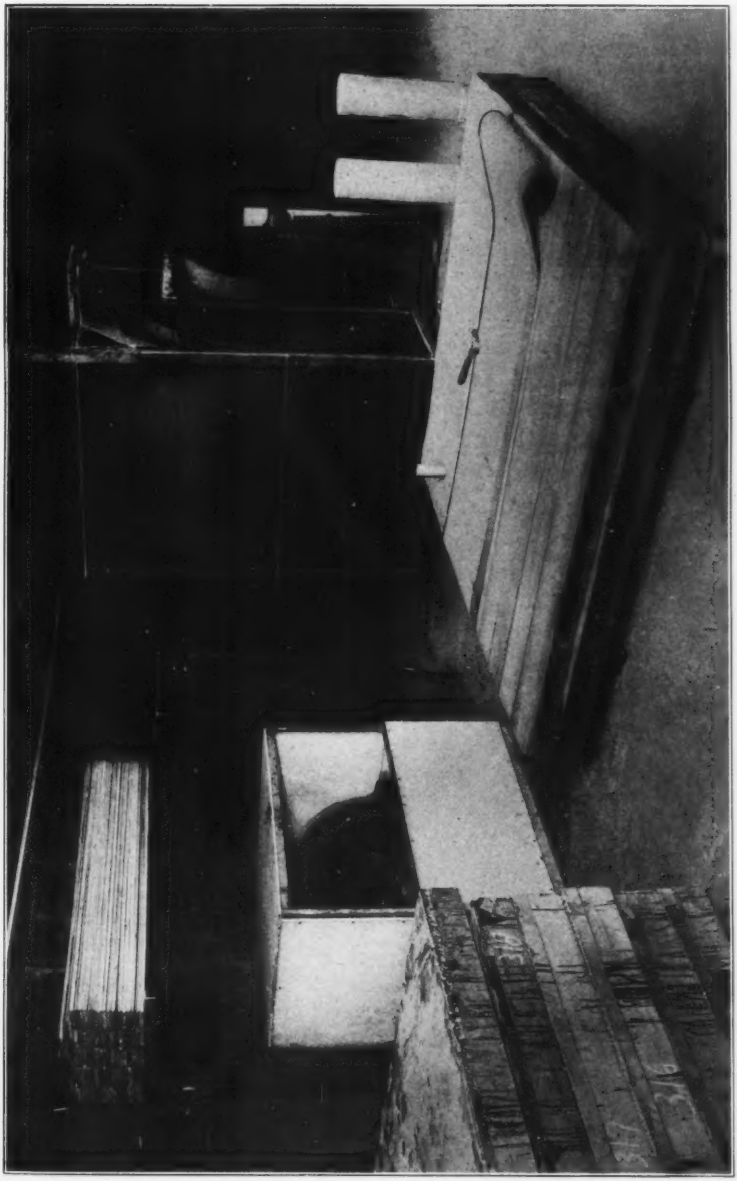


Fig. 2. Applying Sample Roofing to Standard Decks for Tests.

Experienced men are employed to do this work. A pile of completed decks is shown at the left. The motor and fan for securing the wind velocities are shown in the background.

coverings, with a view to determining their practicability and to ascertaining whether there are any particularly objectionable features about the coverings which would be liable to develop weaknesses in actual service. Physical tests of the materials are made to determine their quality and suitability for the purposes for which they are used and fire tests develop the flammability, the liability to carry and communicate fire and the insulation afforded the roof deck. The flying hazard and liability to slip from place when exposed to fire conditions which might actually be expected in the field are studied.

The standard decks on which the roof coverings are applied in the preparation of the samples for tests are seven feet wide by eight feet long and are constructed at the Laboratories as needed (Fig. 2). The lumber is carefully selected for the purpose and stored in a warm dry room so that all of the decks will be in the same condition when used. They are built in a frame so arranged as to evenly space the boards and so that the joints between the boards are the same width in each case.

The roofing is applied to the decks in the same manner as it would be applied upon a building. Where possible, the coverings are applied by representatives of the submittor and, in all cases, by workmen familiar with the particular type of roofing under investigation. Samples are always constructed in the presence of an engineer of the Laboratories who takes careful notes of the work as it progresses, observing particularly the attachments, tightness of the joints and all other features which have a bearing upon the merit of the roof coverings. After the samples have been prepared, they are stored in a warm, dry room for at least 30 days and permitted to season before they are tested.

Roof coverings on buildings may be subjected to the radiant heat from a nearby fire fanned by a light or perhaps a stiff breeze. To approximate this condition as nearly as possible, a radiant heat test is made on the roofing while it is exposed to air currents of greater or less velocity. A sample of roofing constructed as already described is shown undergoing such a test in Fig. 3.

In this test the sample is placed twelve inches from a circular plate 36 inches in diameter which forms the bottom of a circular gas furnace which is mounted on trunnions. The plate is heated to a temperature of approximately 1200 degrees Fahr. by means of the furnace. The sample is thus exposed until the covering fails to longer protect the roof decks and flame develops on the under side. The operator in the center of the picture is observing the rate of spread of flame on the surface of the sample and has just recorded the time at which the covering ignited. The operator at the left of the picture is observing the temperature at the surface of the plate. The temperature is controlled by regulating the gas and air supply by means of valves, one of which is shown in the upper corner of the illustration. The operator in the back of the picture is observing the condition on the under side of the sample and will note the time at which the sample fails. Fig. 4 pictures the results of a radiant heat test upon a roofing sample.

Fig. 3. Making a Radiant Heat Test.

The temperature of the circular plate at the lower part of the gas furnace is approximately 1200 degrees, Fahr.

Fig. 4. Sample of Roofing after Radiant Heat Test.

The picture at the left was taken after the test was completed; the picture at the right indicates the condition of the under side of the roof deck after test. Wind velocity 40 miles per hour.

The air currents used in the test just described and in others are provided by a huge fan driven by a 40-horsepower electric motor. This fan drives the air down a large sheet-iron duct (Figs. 1 and 2), and upon the sample under test. Before the wind machine was used in tests the velocity of the air was measured by means of a series of Pitot tubes placed at the end of the air duct. The speed of the fan which gave the desired wind velocities was then determined. During tests, the fan is regulated to the proper speed by means of a rheostat and maintained constant throughout the test. The fan is equipped with a dial which enables the operator to check readily the number of revolutions.

Buildings adjacent to or near a burning building are quite liable in case of a strong wind to have burning brands fall upon their roofs. In performing this test the burning brand is made up of 2 by 2-inch maple strips formed into a grid, the strips being approximately 1¾ inches apart and held together by similar strips to which they are nailed. The brand is approximately three feet square. The brand is ignited by placing it in a gas furnace four feet square as shown in Fig. 5. This furnace is heated by a grill of gas jets which form the bottom of the furnace chamber.

The brand is supported above the jets and is exposed to the heat of the furnace for eight minutes, by which time it is all aglow and completely covered with coals. The furnace door is tilted out of the way and the glowing brand is lifted from the furnace by means of grapples and tackles suspended from above and placed in the proper position on the surface of the roofing sample. The brand is permitted to burn until entirely consumed or until the roof covering has failed by permitting the ignition of the deck boards on the under

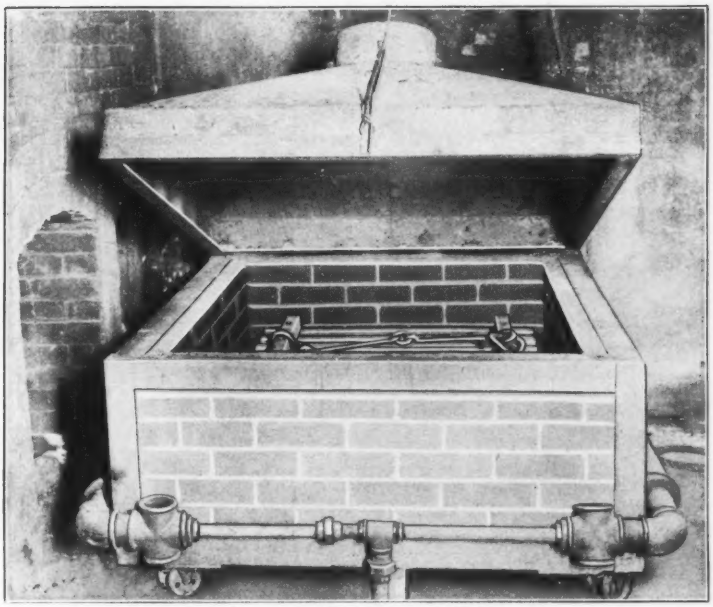


Fig. 5. Furnace for Igniting the Burning Brand.

After being ignited in the furnace the burning brand is placed on the sample roof deck, and air currents of the desired velocity applied.

side. One operator carefully notes the time of ignition and the spread of flame on the surface of the covering, also the rate at which the brand is consumed. Another operator observes the condition of the sample on the under side. Fig. 6 shows the condition of both sides of a sample after test.

To observe the behavior of roofing under the action of flame playing directly upon it as might occur on a building roof, a direct flame contact test is made.

The apparatus used in subjecting samples of roof coverings to direct flame contact is illustrated in Fig. 7. This apparatus consists of a burner with an orifice 36 inches long and ½ inch wide from which a gas flame is emitted. The flame passes over the surface of the sample directly exposing the semi-circular area about 36 inches wide by 18 to 20 inches high. The sample is set in place before the apparatus and the burner is ignited. The sample is thus exposed until the covering fails and the deck boards are ignited. One operator observes the time of ignition of the covering and the rate of spread of flame over the surface while another operator observes the under side of the deck and notes the time in which the deck boards take fire. The effects of such a test are evidenced in Fig. 8.

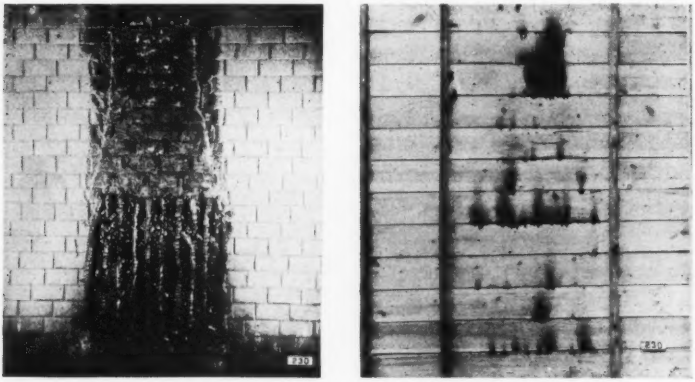


Fig. 6. Results of a Burning Brand Test.

Exposed and unexposed side of roof deck after test. Wind velocity five miles per hour.

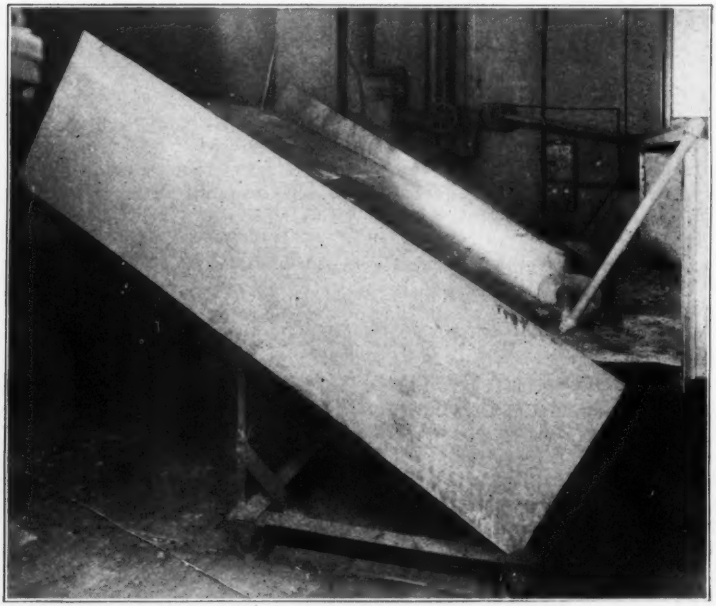


Fig. 7. Flame Exposure Test Apparatus in Action.

With air currents adjusted the flames are regulated by a gas valve to bathe the desired area of the test sample.

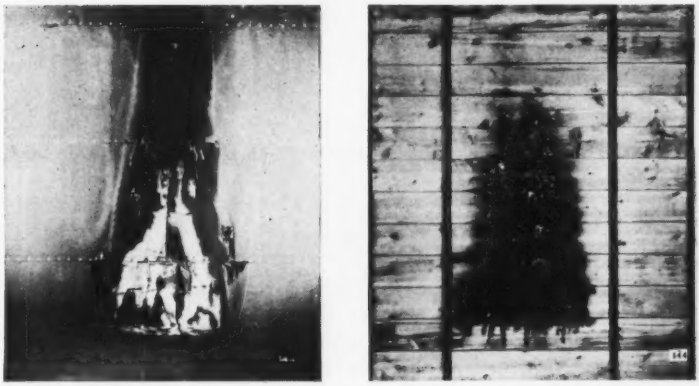


Fig. 8. Effect of a Flame Exposure Test on a Roofing Sample.
Wind velocity five miles per hour.

In all, six tests are made on each covering; that is, two radiant heat tests, two burning brand tests and two direct flame contact tests. In one test of each set of tests the samples are exposed to air currents of 5 miles per hour, while in the other test air currents of 40 miles per hour are employed.

During the tests notes are constantly taken bearing upon the ignition and spread of flame over the surface of the covering, the volume and extent of smoke given off from the covering is recorded, the presence and spread of coals on the edges of the deck boards is noted, the time of ignition of the deck boards is taken and flying of the coverings in a flaming condition or slipping of the covering from place as a result of exposure.

From these notes the flammability of the covering, heat insulation afforded the roof decks, flying hazard, liability of slipping, etc., are determined according to systematically prepared schedules and the coverings are classified as A, B or C according to their behavior during the tests.

The Underwriters' Laboratories' Standard for Roof Coverings has been in operation for about two years. During that time more than 300 samples have been tested and the product of 30 or more submittors has been reported upon and classified. All classes of roofings are represented in coverings that have been reported upon favorably and are now listed in the semi-annual List of Inspected Mechanical Appliances published by Underwriters' Laboratories and in their card advice system, copies of which are on file with every insurance company or organization, inspection department and governmental bureau subscribing to the work of the Laboratories.

Roofings and roofing materials used in the coverings listed are regularly inspected by representatives of the Laboratories at the factories where they are manufactured and the product conforming with the specifications may be recognized by uniform labels attached

to each package. These labels indicate the class to which the roof coverings have been assigned.

Roof coverings which have been examined include the following:

Built-up Types.

Coal-Tar Pitch and Felt Roof Coverings, 5-ply with Gravel Surface.

These roof coverings are made up of five or more layers of tar-saturated rag felt, cemented together, and surfaced with straight-run coal-tar pitch into which gravel or crushed slag is imbedded, the whole being secured to the roof deck according to definite and specific directions. Coverings of this type are limited to relatively flat inclines owing to the character of the surface and the nature of the materials of which they are composed. They are constructed in a great variety of ways, and materials having quite different properties are employed in the various types, with the result that, from a fire protection viewpoint, there is considerable difference in the merit of the coverings. Roofings composed of as low as three pieces of felt of light weight and of pitch fluxed with soft materials are frequently found. These should not be confused with coverings constructed of a larger number of plies in which standard materials are used, for they do not possess the same fire protective value.

Asbestos-Asphalt Roof Coverings—Smooth Surface.

These coverings can be used on relatively steep inclines where suitable attachments for the coverings are obtainable. The coverings consist of a laminated membrane composed of three or more plies of asbestos-impregnated felt cemented together with an asphaltic compound, all constructed in accordance with definite specifications and from materials of definite weight and thickness. These coverings should not be confused with coverings of similar construction in which light felt and compound of low flash and ignition points are used, for they do not possess the same fire-resisting properties as coverings constructed of the standard materials.

Asbestos-Rag-Felt Built-up Roof Coverings.

Roof coverings of this type are made up in a great variety of ways, and their fire-resisting properties differ materially in the form and arrangement and in the character of the materials used. Certain patterns of these coverings are made up of one or more layers of prepared roofing or combinations of saturated felt and prepared roofings. They are usually smooth surfaced and can be laid on fairly steep inclines where the roof decks will receive and retain nails and the design of the covering provides for a permanent attachment of all of the sheets.

Shingle Roof Coverings.

Asbestos-Cement Shingle Roof Coverings.

Coverings composed of asbestos shingles are laid in two ways: namely, according to the American method or according to the

French method. In either case the coverings are composed of overlapping slabs which are fastened together and to the roof deck by means of nails driven through each piece. In the case of the shingles laid by the American method the covering is at least two shingles thick at the thinnest point but when laid according to the French method they are only one shingle thick. Coverings laid according to either method are limited, because of the character of the shingles, to relatively steep inclines and roof decks capable of receiving and retaining nails.

Asphalt-Rag-Felt Shingle Roof Coverings.

Coverings composed of asphalt-rag-felt shingles are usually laid according to the American method and are laid at least two shingles in thickness at the thinnest point. Shingle effects are obtained by the use of slabs, and special artistic effects are obtained by laying either the shingles or the slabs in a special way, in which event the coverings may consist of only one thickness of roof covering.

The shingles are made in a great variety of shapes and surfacing material and the coverings are limited to relatively steep inclines and to roof decks capable of receiving and retaining nails. It should be noted, also, in passing, that asphalt-rag-felt shingles are made in a number of thicknesses and patterns and that some of these shingles are thin and of such shape that they do not possess the same fire-resisting properties as the standard product.

Prepared Roof Coverings.

Asbestos-Asphalt Prepared Roof Coverings.

Asbestos-asphalt roof coverings are made up of sheets of asbestos roofing lapped at the edges and secured to the roof deck and to each other by nails. These coverings are usually smooth surfaced. The sheets of roofing are composed of impregnated asphalt sheets cemented together with asphalt cement. They are made in a number of plies and thicknesses, the fire-resisting properties of the coverings differing according to the thicknesses and weight of the roofing employed. These roof coverings can be laid on relatively flat or steep inclines but are limited to roof decks which will permit of secure nailing down of the sheets.

Asphalt-Rag-Felt Prepared Roof Coverings.

These are made up of sheets of prepared roofing lapped at the edges and held together and to the roof decks with nails driven along the laps. The coverings are finished in a great variety of surfaces. The prepared roofing is composed of a rag felt saturated with asphalt and coated on either or both surfaces with an asphaltic material. The roofing is made in a number of plies or patterns and is either smooth, sanded or grit surfaced, depending upon the character of the surfacing material used. The fire-resisting properties of this type of covering are dependent on the weight and thickness of the covering and the materials of which it is composed. Coverings using light felt and compounds having relatively low flash and ignition

points do not possess the same fire-resisting properties as those composed of standard materials.

Coverings of the built-up, shingle and prepared types include the great majority of the roof coverings now being used. In addition to those mentioned, there are metal roof coverings of various kinds, natural slate roof coverings, tile roof coverings, etc., all of which differ from each other in many essential particulars and have widely different fire-resisting properties.

The raw materials used in built-up roofings consist of rag or asbestos felts impregnated with coal-tar pitch or asphalt, and of coal-tar pitch and asphalt cement. Asbestos felt is rarely, if ever, impregnated with pitch, but rag felts are impregnated or saturated with either coal-tar pitch or asphalt cement. The cementing operation is essentially the same in each case. In the process of manufacture the dry felts are permitted to pass into a bath of heated saturating material and are then passed through a drain or squeeze rolls which remove the surplus saturant. The felt is permitted to cool and is then packed into rolls as the case requires. More or less skill is required in compounding the asphalts and in the operation to obtain the proper degree of saturant or impregnation, as well as in the selection of the compounds so that the finished product will not stick after being packed or be too brittle or too flexible for use.

Coal-tar pitch of standard quality used in roof coverings is manufactured by distilling off the volatile portions of certain grades of coal-tar in kettles of special form. This operation is carried on until the finished product has the desired properties. Skill and experience are required in the manufacture of this material and in the selection of the raw product in order to obtain a suitable pitch.

Asphaltic compounds used in roof coverings are obtained in a number of ways. One method is to distill natural and residual asphalts until they obtain the required hardness and other physical properties. Another process is to flux hard and soft asphalts under heat so as to obtain a compound having the desired physical properties, or to flux asphalts and treat them with air or other oxidizing agents until the finished product is of the proper consistency.

Asbestos cement shingles are made from asbestos fibre and portland cement, the two being mixed together and treated with water. The mixture is then formed into thin sheets or slabs and compressed under heavy pressure with hydraulic rams. After the slabs are compressed, they are stored in a damp chamber until the cement has thoroughly set, after which they are dried, cut to shape, punched for the nails and packed for shipment.

Asphalt-rag-felt shingles and asphalt-rag-felt prepared roofing are manufactured in essentially the same manner. The rag felt is impregnated with an asphaltic compound and then the surfaces are coated with an asphaltic compound having slightly different physical properties. Smooth surfaced roofing and shingles are dusted with a fine powder to prevent sticking in the rolls or packages. Sanded

or grit surfaced roofings have the surfacing material of sand, crushed slate, gravel, etc., rolled into the surface of the sheets while the coating compound is still hot. These roofings are then cut to lengths and packed in rolls, usually a sufficient quantity being put up in a roll to lay one hundred square feet of roof covering. In the case of the shingles, the sheets are cut to the desired size and form and the individual pieces packed in cartons or crates for shipment. Asbestos prepared roofing is usually made of one or more sheets cemented together. The dry asbestos sheets are first impregnated with an asphaltic compound, the same as rag felt. The impregnated sheets are then passed through a machine which cements them together with hot asphaltic compound. The assembled roofing is then cut to length and packed in rolls and crates as the case requires.

An enormous quantity of roofing and roofing materials is used annually. It is estimated by certain associations interested in the promotion of roofing that in round numbers $71,500,000.00 is the value of roofing of all kinds used annually.

Architects, contractors and owners should exercise care in selecting the roof coverings they propose to use. They should consider the durability of the roof coverings, their practicability for the particular type of roof decks on which the coverings are to be applied, exposure to fire and weather to which the coverings are liable to be subjected, and then select the type of roof covering which is best adapted to meet the particular conditions in question.

Materials for roof coverings inspected and classified as standard bear one of the labels as illustrated attached to each package. The "List of Inspected Mechanical Appliances," issued periodically by Underwriters' Laboratories, and containing particulars of the classifications and the names of manufacturers of approved products may be obtained on application from the Laboratories at 207, East Ohio Street, Chicago.

Munitions Factory Fire and Explosion, London, England.

[This interesting censored account of the recent munitions factory disaster in London is taken from the February issue of our British contemporary *Fire*]

There occurred in the east end of London on Friday, January 19th, just before 7 p. m., an outbreak of fire, supposed to have been started by a small explosion on premises occupied by manufacturing chemists. The premises occupied an area of about 1,000 feet by 300 feet, and as a munition factory would be classed as comparatively small. The explosives stored there were also comparatively few in quantity although of high power, and were concentrated in the neighborhood of the outbreak of fire.

Immediately on the outbreak of fire, steps were taken to deal with it by the works' fire brigade, and the comparatively new public fire brigade station situated about 400 feet from the locality of the outbreak received notification. Simultaneously with the measures taken to subdue the outbreak, warnings to escape at once were given to those workpeople in the premises. These numbered forty-three, being the last few of the day staff who were leaving just previous to the commencement of the night shift. The works' fire brigade had got to work from a hydrant, and the public fire brigade were also getting to work with a turbine motor pump off a hydrant in the roadway about 200 feet from the scene of the outbreak. The flames spread very rapidly, and involved some explosives in the immediate vicinity.

Within about six minutes of the outbreak a violent explosion occurred, followed quickly by other explosions. The immediate result of these was to wreck and fire the premises of the manufacturing chemists; also an adjoining range of buildings consisting of one, three, and five floors, 600 feet by 300 feet; a range of buildings, 1,000 feet by 480 feet; a building of two floors, about 1,200 feet by 100 feet. Other buildings were more or less damaged by the explosion, and fires broke out in some. The public fire station and firemen's houses adjoining were wrecked, also several other dwelling houses, and the cottages in about a dozen short streets in the vicinity suffered damage from flying debris and air concussion; almost every window was broken, and a few roofs and ceilings collapsed.

The central area of damage (about one-sixth of a square mile in extent) was occupied by the buildings referred to, but as they were widely detached the force of the explosion mostly spent itself upon them. But the total repercussion area extends for about five-sixths of a mile in length and an average of one-fifth of a mile in depth, the principal property damage, apart from the buildings referred to, being to windows.

The explosion caused a temporary dislocation of telegraphic and telephonic communication; wrecked the motor pump in the roadway, and otherwise interfered with the work of fighting the outbreaks of fire which quickly arose in several directions. But very little time elapsed before an adequate force of firemen with appliances was on the scene, the pumping apparatus including twenty motor pumps, four fire floats, and a land steamer. There were several district-call outbreaks blazing simultaneously in the area, but they were got well in hand before midnight, some remarkably good stops being eventually made. Within two days business was resumed in the undamaged parts of some of the premises involved. The total amount of property damaged it is estimated will exceed a million pounds, but will not reach more than one-tenth the value a preliminary inspection of the area involved might lead one to anticipate.

The casualty list is heavy, but not so large as might have been expected considering the number of persons within the directly affected area at the time of the explosion. Only forty-three members of the day staff remained in the premises where the outbreak occurred (twenty-three of these are safe), and most of the other factories were almost empty of workpeople. The alarm of fire had drawn many people from their houses into the street; the majority of the workers had not arrived home, and not a great number were congregated round the scene of the fire. Consequently when the explosion occurred there were comparatively few inmates in the houses which collapsed, but many persons were injured by flying debris, the heavier portions of which consisted mostly of girder steel and burst boilers. The total casualties were:—Killed, 44 men, 12 women, 14 children; Injured, 174 men, 136 women, 90 children. Total: 70 killed, 400 injured. Amongst those killed were two of the firemen on the damaged motor pump, five other members of the crew being also injured. The daughters of two firemen were also killed by the collapse of the firemen's dwellings. An army of assistance, comprising the military, police, and civilians, was quickly organized to rescue from the debris victims of the explosion. Ample first-aid-to-the-injured arrangements were also soon made, and hospital accommodation provided.

The effects of the explosion, other than those described, form interesting observation.

The building in which the explosion occurred disappeared, and an immense crater, 100 feet by 30 feet by 15 feet, has been formed, the displaced earth having been apparently mostly forced into the sides of the crater, causing a miniature seismic wave and buckling upward the roadway above. The chemical factory otherwise has merely collapsed, and little fire seems to have occurred amongst the debris here.

The factory buildings which collapsed on other properties were fired by electric shorts, gas leaks, flaming brands of debris, debris friction, dismantled forges, broken boiler furnaces, etc.

Several boilers burst, the huge carcases being thrown to considerable distances. Fragments of boilers, ten to fifteen feet long,

are to be seen promiscuously scattered around. A peculiar feature of the fire-tube boiler carcases is that the ends of the tubes in the fire-box are pinched and closed up as if, being subjected to the direct heat of the furnace earlier than the exhaust ends, they gave more readily to the expansive force of the steam at the moment of bursting. All the boilers seem to have given way first at the furnace end, and have come adrift from the fire-boxes. The fire-boxes, being anchored, were apparently shattered, but the boilers were projected into space.

The triumph of ferro-concrete construction is the most striking feature of the catastrophe. Not only have such structures within the explosion area withstood the effect of the air-wave, but they came through the ordeal of fire successfully. The metallic rods and laths within the concrete enabled the buildings to give slightly to the air-wave when it struck the buildings; the windows caved in. The reverberating air entered, and expanding passed through the opposite windows, thereby helping to straighten up the main structure again although fire was left behind. The fractures in the structures are only where the fires were fiercest, due to the nature of the contents. Brick structures collapsed ignominiously, being pulled inward by the floor and roof joists and girders. But brick chimney stacks, because they have no upper strain, without exception exist practically undamaged, having been able to give slightly to the force of the air-wave and then spring back to perpendicularity.

Single-storey warehouse sheds which were closed on both sides collapsed on the side which met the blast of the explosion, but sheds closed only on the side furthest from the explosion merely had the side blown out. Sheds open on both sides suffered very little, as was to be expected.

The roofs of buildings, including dwelling-houses, were lifted by the excess internal air pressure set up by the air blast passing in through windows and doorways. Not all the 100,000 windows broken were blown in; many were blown out by the advance wave entering open doors and creating a preliminary high internal pressure, sufficient to burst out some windows before the main blast arrived and blew in the remaining windows. Some of the houses nearest the scene of the explosion had also burst in walls, but further away the houses showing structural damage other than by flying debris suffered from burst out walls.

The motor fire engine involved had only the superstructure damaged by flying debris, and is being repaired. It is a Dennis turbine, and is the second to be involved in a munition works fire. The other, it will be remembered, was damaged by the Yorkshire explosion, six members of the crew being killed and twelve injured, including the Chief Officer and Superintendent.

Fig. 1. View of the plant before the fire.

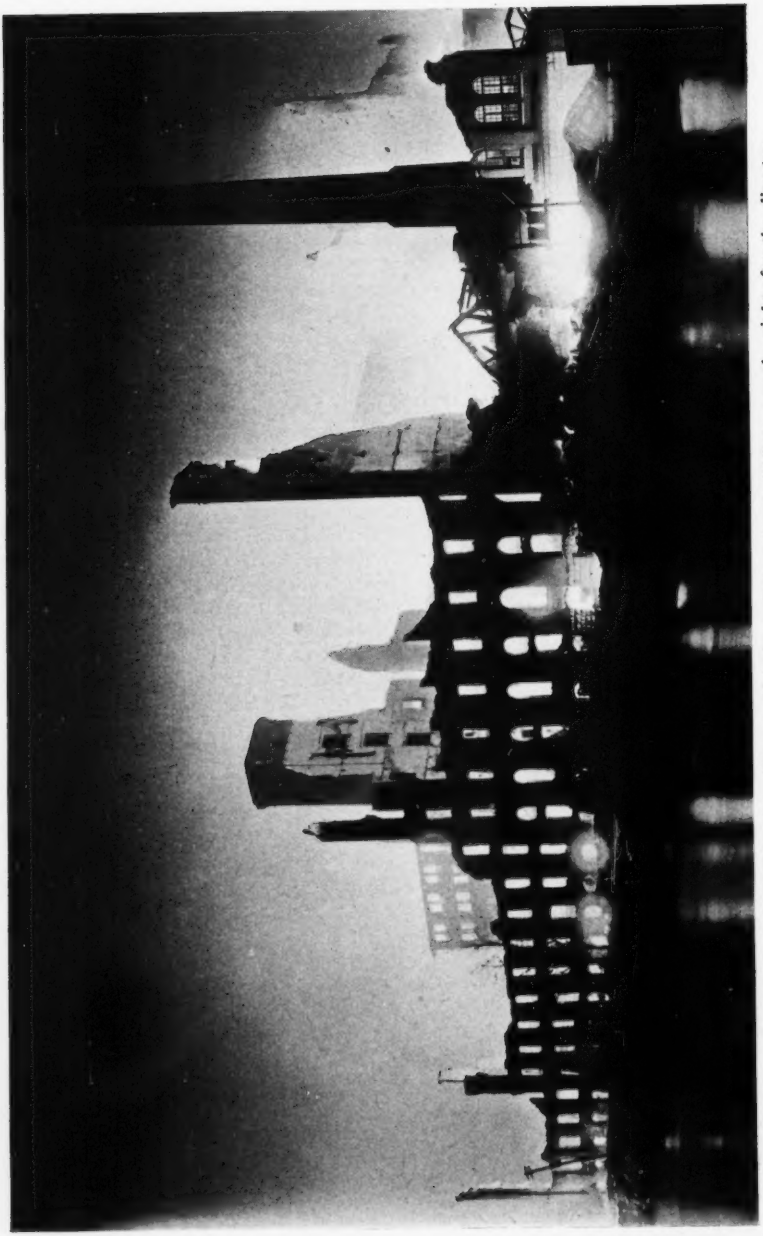
Quaker Oats Co. Fire at Peterboro, Ontario,

December 11th, 1916.

Special Report by Canadian Fire Underwriters' Association, A. J. Mylrea, Inspector.
(Member N. F. P. A.)

History of Plant. In 1900 the Quaker Oats Co., controlling the American Cereal Company, began the erection of a plant at Peterboro, Ontario, which was placed in operation in 1902. The head office of this concern is located in Chicago, Ill. Branch plants are located at Cedar Rapids, Iowa; Fort Dodge, Iowa; Akron, Ohio; Battle Creek, Mich.; Joliet, Ill.; Morris, Ill.; Richford, Vt.; and Saskatoon, Sask.. The original Peterboro plant consisted of the basement and first three stories of Warehouse No. 1 and of the Mill, Dry House, Boiler House, Cleaning Mill and Elevator "A", as they existed immediately preceding the fire. In 1907 the fourth story was added to Warehouse No. 1 and Warehouse No. 2 was built.

Fig. 2. View of the plant after the fire.



View of the ruins of the Quaker Oats Plant at Peterboro, Ont., taken at 10.3 p.m. on the night after the disaster.

Elevator "B" and the basement and first four stories of the Concrete Warehouse were erected in 1910, and early in 1916 the 5th and 6th stories were added to the Concrete Warehouse. At the time of the fire there was under construction adjoining the west side of Elevator "A" a reinforced concrete roof, supported by reinforced concrete columns, to shelter the railway weigh scales.

Description of Plant. The major portion of the plant consisted of a row of buildings and several detached ones located on the west bank of the Otonabee River between Hunter and Murray Streets; and a hydro-electric station belonging to the company, which furnished the motive power for the plant, was located at a dam about one-quarter of a mile up stream. (See Fig. 1 and Plate I). The row of buildings, which was located about 60 feet from the water's edge consisted of: 1st—**Warehouse No. 2,** which was of brick and semi-mill construction, basement and four stories in height, and fitted with plain glass windows in wooden sash; 2nd—**Warehouse No. 1,** which was similar in construction; 3rd—the **Mill,** which was brick, semi-mill construction, basement—six, equal to eight, stories high, and provided with plain glass windows in wooden sash on both sides of the building and in the windows overlooking Warehouse No. 1; 4th—the **Dry House** (where the fire started) which had brick walls, 4-inch reinforced concrete floor slabs on unprotected steel beams and columns, semi-mill roof, basement—five, equal to eight, stories in height, and which had plain glass windows in all exterior walls except in that part of the 5th story occupied by the stock tanks and below the Boiler Room roof in the north wall, the windows in the west wall being provided with standard wood tin-clad shutters; 5th—**Boiler House,** having brick walls, one, equal to two, stories in height, plank on steel trussed roof, and with plain glass windows in the exterior walls—all the buildings adjoining from south to north in the order given. The **Pump House** was a low one-story brick building adjoining the northeast corner of the Boiler House. These buildings were all separated by brick fire walls, parapetted two to three feet above the roof; and communicating door openings were protected by standard automatic sliding wood tin-clad fire doors. For further details of construction see Plate II.

Thirty-eight feet west of this row of buildings and extending from a point near the south end of Warehouse No. 2 to a point about even with the middle of the Mill was located the **Reinforced Concrete Warehouse.** This building was basement and six stories in height and was equipped with wired glass windows in metal frames on the exposed east wall, the north wall being blank. The windows in south and west walls were plain glass in wooden sash with the exception of two vertical rows of wired glass metal sash windows in the north bay of the west wall. The Concrete Warehouse communicated with Warehouse No. 2 in the third story by means of an enclosed reinforced concrete bridge equipped with a wood tin-clad fire door on the east end only; and also communicated with the Mill by means of a concrete tunnel provided with a wood tin-clad fire door also at the east end only.

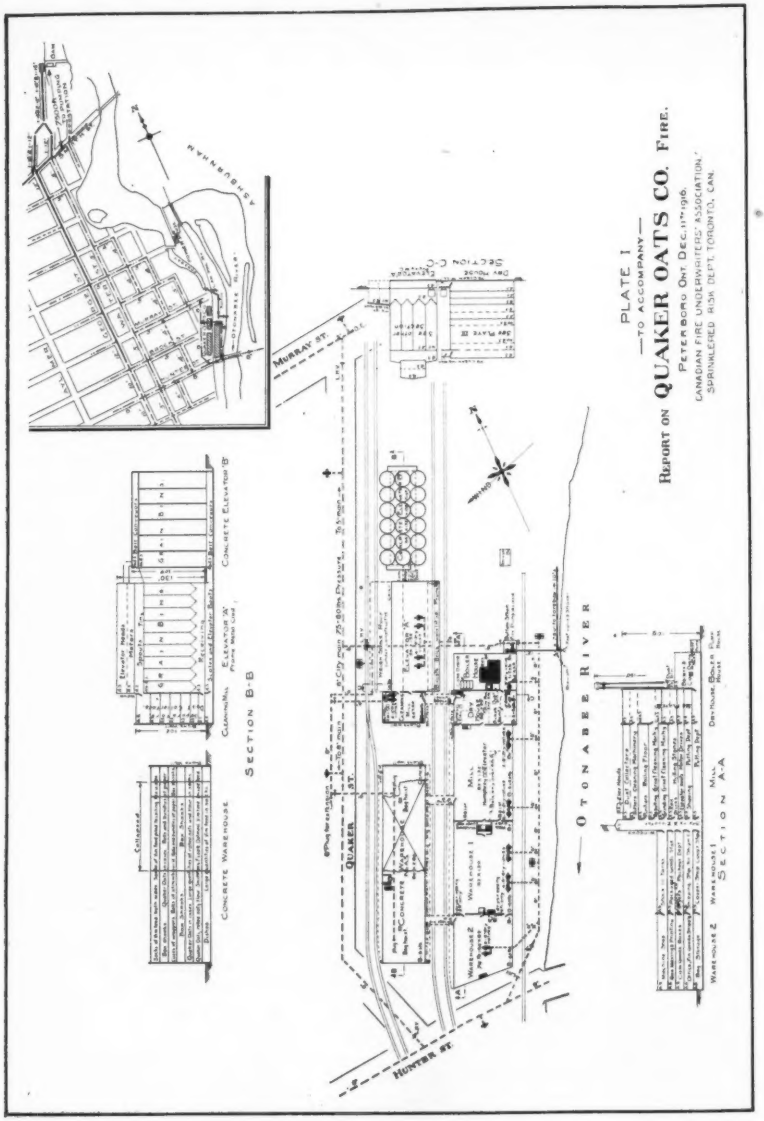
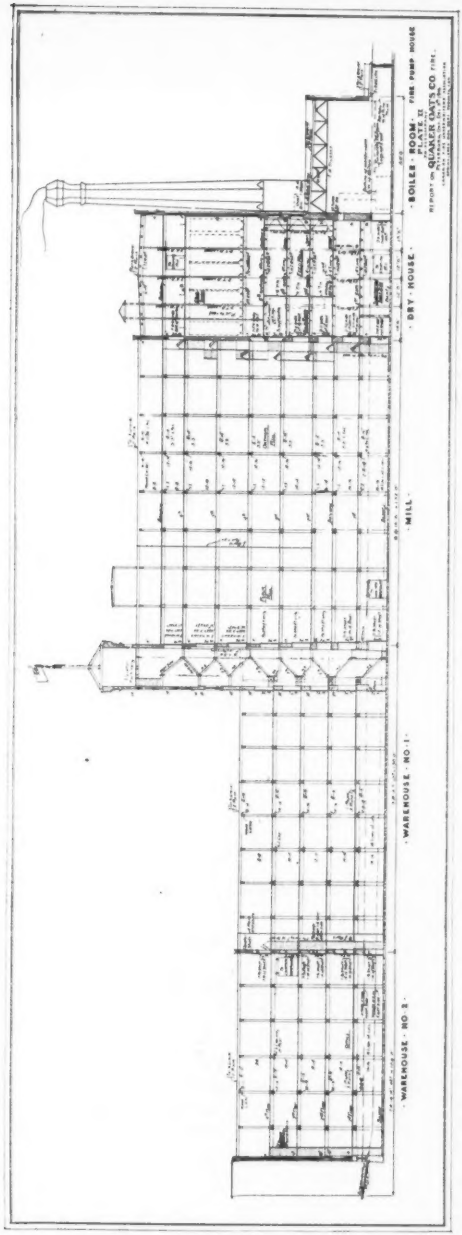


PLATE I
—TO ACCOMPANY—
REPORT ON QUAKER OATS CO. FIRE.
PETERBORO ONT DEC 11TH 1916.
CANADIAN FIRE UNDERWRITERS' ASSOCIATION.
SPRINKLERED RISK DEPT. TORONTO, CAN.
SECTION B-B
SECTION A-A
CONCRETE WAREHOUSE
CONCRETE ELEVATOR 'B'
ELEVATOR 'A'
MURRAY ST.
QUAKER ST.
HUNTER ST.
OTONABEE RIVER
ASHBURNHAM



In line with the Concrete Warehouse and approximately 60 feet north of it was situated the **Cleaning Mill**, a brick basement—six, equal to eight, story building of semi-mill construction. The south wall was blank, as was also that portion of the north wall serving as a division wall between this building and Elevator "A". In the east and west walls, and in the exposed portion of the north wall were a number of plain glass windows in wooden sash. The windows in the east wall were provided with standard wood tin-clad shutters. The Cleaning Mill communicated with the Dry House by means of an enclosed overhead bridge in the top story, which was provided with a fire door at each end. In the basement was a stone tunnel which also communicated with the Dry House and had a fire door at each end.

Adjoining the Cleaning Mill on the north and offset 20 feet to the east was **Elevator "A"**. The first story of this building was brick and the remainder wooden crib construction, metal clad. There was a fire wall between this building and the Cleaning Mill. The door openings were protected by fire doors, but there were several unprotected screw conveyor openings. The building was approximately 130 feet high and had plain glass windows overlooking the Cleaning

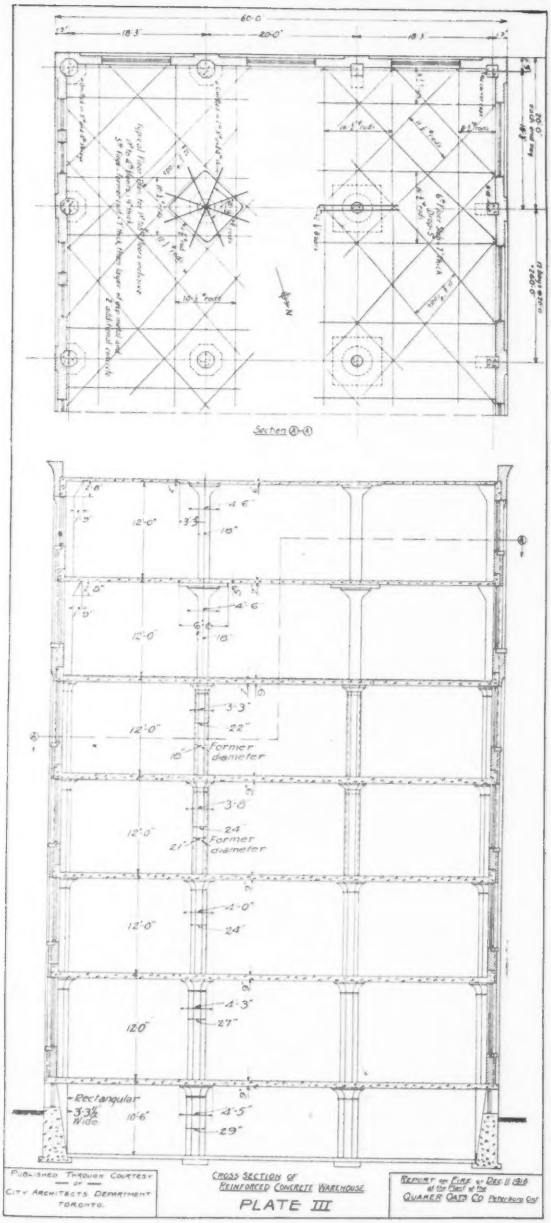
Mill and also in the other three sides above and below the grain bins.

Twenty-four feet north of Elevator "A" was reinforced concrete **Elevator "B"**, which consisted of eighteen circular bins of approximately 22 feet outside diameter by 100 feet high, surmounted by a conveyor passage 9 feet in height. Elevator "B" communicated with Elevator "A" by means of a concrete tunnel in the basement, by an enclosed overhead concrete conveyor passage and by an open steel foot bridge beneath the conveyor passage.

The constructional details of the eastern row of buildings is shown on Plate II. Especial attention is called to the two unprotected package dryer openings, each 18 inches by 48 inches, in the 2nd story between Warehouses No. 2 and No. 1, and to unprotected window openings overlooking Warehouse No. 1 in the south wall of the Mill and also in the south wall of the elevator tower. The balcony between the first and second floors of the Mill was built by degrees as the plant grew until it became a separate floor although still retaining the name "Balcony." Above the sixth floor of the Mill was another balcony covering approximately 70% of the floor area. The elevators in the Mill, Dry House and Cleaning Mill were all unprotected.

Plate III gives the constructional details of the reinforced Concrete Warehouse.

This building was of the "four-way-flat-slab" type, 60 feet by 280 feet; basement and six stories in height. First four stories built in 1910, upper two in 1916. **Walls**: Basement, concrete, 18 inches at top, 36 inches at bottom, battered on inside; remainder 14-inch brick curtain walls, parapetted 3 feet above roof and carried at each floor on 9-inch by 21-inch reinforced concrete spandrel beams which were integral with floor slab and also stiffened exterior edges of same. **Floors**: Basement concrete; 1st, 2nd, 3rd and 4th floors were 9-inch slabs; 5th floor—former roof—was originally a 7-inch slab changed in 1916 to 9-inch; 6th was a 7-inch slab increased to 12 inches in thickness in vicinity of column heads. **Roof**: 6-inch slab with center drainage, covered with tarred felt, no gravel. All floors except basement were reinforced with bands of half-inch round rods running from column to column both directly and diagonally, near the top of the slab in the column head area and near the bottom of the slab between the columns. The 5th floor slab was changed from 7 inches to 9 inches in thickness by laying wire netting on it and pouring on another 2 inches of concrete. **Columns**:. For details of column sizes, see Plate III. When the two upper stories were added, the 3rd story interior columns were increased to 24 inches short diameter, and the 4th story interior columns to 22 inches, short diameter, by wrapping them in expanded metal and pouring around them a grout composed of cement and gravel screened through a half-inch screen. The wall columns in the 5th and 6th stories had brackets to help support the 6th floor and roof slabs. All other columns except basement wall columns had flared heads for the same purpose. Brick pilasters on the outside hid the wall columns from view.


Section ⓑ-ⓓ
Former diameter
Former diameter
Rectangular
Published Through Courtesy of City Architect's Department Toronto.
Cross Section of Reinforced Concrete Warehouse
PLATE III
Report on Fire at Dec. 11 1919 at the Plant of the Quaker Oats Co Peterboro Ont

The coarse aggregate used in the concrete was a limestone gravel procured from a neighboring pit; it was clean and fairly well graded, some crushed limestone being mixed with it. The cement used was a first-class, quick-setting, strong cement. In the first four stories medium steel was used and in the 5th and 6th stories steel rolled from the arbitrary discard of munition stock was used, which is somewhat stronger than the medium grade. In general there was about one inch of fireproofing to the slab rods and the class of workmanship on the whole was good.

Openings: Near the west wall, in the 5th bay from the south end was a stairway provided with 2½-inch automatic wood tin-clad trap doors. The stair stringers were steel channels with 2-inch wooden treads. In the 6th bay from the south end, adjoining the west wall was an elevator tower 8 feet 6

Fig. 3. Spalled column and unprotected bag hoist on right.

inches by 10 feet 6 inches, inside measurements, enclosed in 14-inch brick walls, carried on each floor. The doorways to the shaft were equipped with 2½-inch wood tin-clad fire doors in the basement and first four stories and with corrugated steel doors in the 5th and 6th stories. Two bag hoists were provided, basement to 6th floor, in the middle aisle and about one-quarter the distance from each end of the building. These were operated on the endless chain principle and the openings in the floors —3 feet by 6 feet 6 inches, were unprotected, as can be seen from Figure 3. There were four chutes between the 1st and 2nd floors, but as these were not used, the hatches were always closed.

Communications: There was a concrete bridge in the 3rd story in the fourth bay from the south end, leading to Warehouse No. 2 and a concrete tunnel in the basement communicating with the Mill, as described before.

Windows: The north wall was blank. In the east wall in all stories the windows were wired glass. Hollow metal sash was used for the basement and 1st to 4th stories, inclusive, and solid steel sash above. In the south wall and in the west wall, in all stories, plain glass in wooden sash was used, except for two vertical rows of windows in the north bay of the west wall. These windows and sash were similar to those in the east wall.

Since the Hydro Electric Power House, owing to its distance from the rest of the plant, was not affected by the fire, it will not be considered further in this report.

On the west side of Quaker Street the ground rose sharply to a height of about 35 feet and then sloped upward more gently. At a distance of from 200 feet to 500 feet from the plant were located a number of frame and brick residences and the Court House, as may be seen in Figure 2.

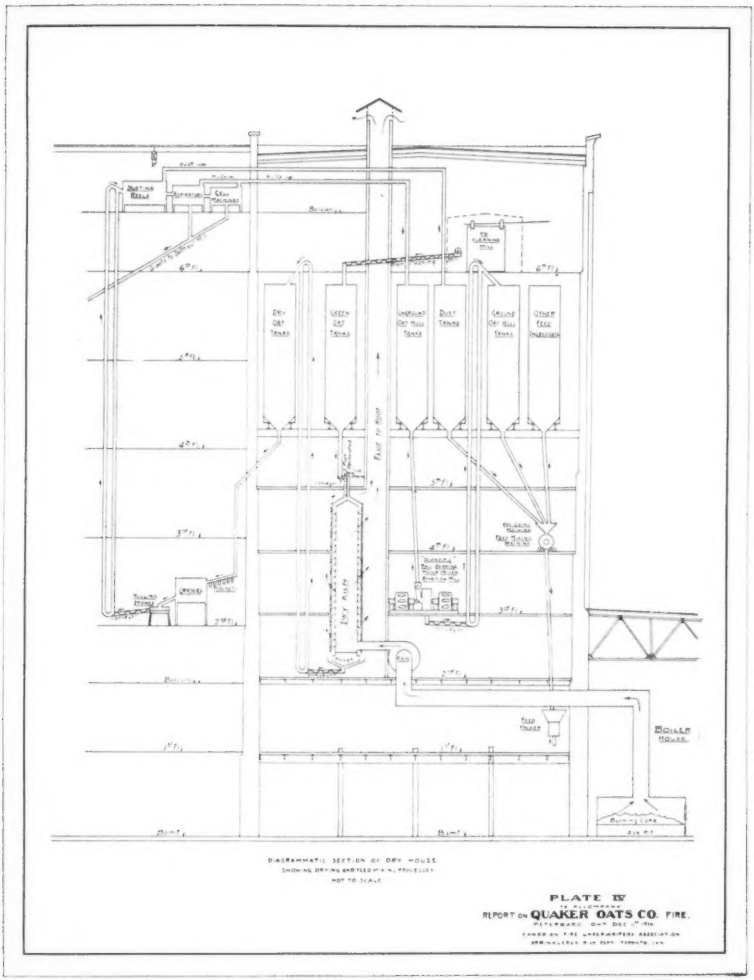
Occupancy and Processes: The plant as a whole was occupied for the storage of grains, manufacture of flour and various cereal products such as rolled oats, oat meal, puffed rice, puffed wheat and corn puffs, with their attendant by-products, manufacture of barrels, boxes, cartons and paper packages used as containers for the finished article and for the storage and shipping of finished goods. The sections on Plate I accompanying this report show the occupancy of the various buildings. It will be noted, upon referring to Plate II, that the Flour Mill was simply a portion of the Mill partitioned off from the Oat Meal Mill by a 7/8-inch board partition.

The grain was received in Elevator "A", stored either in this building or in Elevator "B", whence it was sent to the Cleaning Mill where it was cleaned and separated. The wheat was taken direct from the Cleaning Mill to the Flour Mill while the oats went through a special process in the Dry House before going to the Oat Meal Mill. The manufactured product from the Flour Mill, Oat Meal Mill and Puffing Departments were sent to the Warehouses for packing and shipment.

The concrete building was used solely for storage purposes, shipment from storage being conducted on the 1st floor. In the basement were dishes for premiums, some bales of scrap paper and north of the elevator a large quantity of "Vim" feed. The 1st and 2nd floors were heavily piled with sacks of rolled oats, flour and feed. The 3rd and 4th floors were used to store supplies for the Package Department, the 3rd story being nearly filled with piles of collapsed wooden boxes—"box shooks" as they were called—and the 4th floor having box shooks, cases of wrappers, bundles of paper, rolls of straw board and rolls of paper. The 5th floor was but partly filled, containing some box-shooks, rolls of paper, and cases of Quaker Oats. North of the elevator and down both side aisles south of the elevator, the 6th floor was piled full of sacked "Vim" feed.

The floors were designed for 200 lbs. per square foot of live load, but piled to the ceiling as they were with bags of hulled oats and flour the load on the 1st and 2nd floors varied from 247 lbs. to 340 lbs. per square foot, and on the 4th and 5th floors several panels containing rolls of paper had a load of 258 lbs. per square foot. The loaded area of the 6th floor carried about 175 lbs. per square foot of live load. On all floors, but the 6th, a 10-foot trucking space was reserved down the center of the building, putting the heaviest strain on the wall panels; and according to the testimony of the stock checker, the bulk of the stock, on all floors but the 1st, was in the north end of the building.

The diagrammatic sketch, Plate No. IV, shows more in detail the Dry House process and part of the process in connection with the Oat Meal Mill. The grain coming from the Cleaning Mill entered



the green oat tanks and from there was spouted to the Drying Kilns. As it entered the dryer it was moistened by steam and passed downward by gravity over a series of veins to a collecting trough at the bottom. The gas from the coke furnaces was forced upward into the perforated sheet-iron tube to which these veins were fastened, passed through these perforations, through the descending grain and out through openings in the outer tile wall of the dryer to the open space of the kiln room. Thence it passed through tile flues to the open air above the roof. The dried oats in the collecting trough

were collected by a sweep and conveyed to an elevator which delivered them to the dry oat tanks. From these tanks the grain was drawn, as required, through magnetic separators to remove any bits of steel, then through various sizers and graders to the hulling stones in which the hulls were split ready for removal from the groats. Another elevator then conveyed them to the dusting reels located on the upper balcony of the Mill, where the dust was removed. The dust was carried over to dust tanks located in the Dry House while the hulls and groats passed on to aspirators and cell machines which removed the hulls from the groats. The groats were then put through the regular milling processes while the hulls were conveyed to unground hull tanks in the Dry House. From here the hulls were spouted to the attrition grinders located on the 3rd floor of the Dry House. A fan was connected with these grinders for the purpose of drawing away dust that might otherwise have accumulated and deposited it in a dust bin on the roof of the Boiler House. The ground hulls passed from the grinder through the floor to an elevator which deposited them in the ground hull tanks. These attrition grinders were the ones in which "puffs" frequently occurred.

Various feed ingredients such as ground corn, ground barley, cotton seed meal, which were stored in other tanks were drawn to the same automatic weighing device as the dust and ground hulls and after being weighed out in the proper proportions would go to the mixing conveyor on the 4th floor and from there to the feed packers located on the 1st or shipping floor.

Fire Protection.

Inside Protection.

Automatic Sprinklers: Except as noted below, Warehouses No. 1 and No. 2, the Mill, Dry House, Boiler House, Cleaning Mill and Elevator "A" including tops of all elevator legs throughout the plant, were equipped with Grinnell 1901 and 1906 automatic sprinklers. The two frame, tin-lined package dryers, each 18 inches by 48 inches by 80 feet in the second story of Warehouse No. 1, the walkways over stock tanks and grillage under them in the Dry House, the substation in the basement of the Dry House, the dust bin over the Boiler House roof and concrete platform inside Boiler Room, Fire Pump House, concrete bridge in 3rd story between Warehouse No. 2 and the Concrete Warehouse, tunnels between the Mill and Concrete Warehouse and between the Dry House and Cleaning Mill, the floor of elevator "A" over the grain bins, and concrete weigh scale adjoining Elevator "A" on the west (under construction at the time of the fire) were unsprinklered. The Concrete Warehouse and concrete Elevator "B" were entirely unsprinklered. The Boiler House was protected by a wet pipe sprinkler system; the remainder of the sprinklered portions of the plant were dry pipe, fifteen 6-inch and two 4-inch Grinnell Differential dry valves being used. The dry valves in Warehouses No. 1 and No. 2, Mill and Cleaning Mill were installed in pairs, each pair being supplied by a 6-inch connection from the 8-inch underground yard main, while in Elevator "A"

there were four dry valves on one header supplied by one 6-inch connection, and in the Boiler House there was one 6-inch connection for the wet pipe sprinklers in this building and for the dry valve which controlled the sprinklers in the Dry House. Each dry valve could be shut off by a gate valve directly underneath it, and in every underground connection to the dry valves from the private yard main there was an indicator post gate located approximately thirty-five feet from the building supplied. As may be seen in Plate No. II absolute pockets were formed in all ceilings except the roofs of the two Warehouses, the Mill and Cleaning Mill. These pockets varied from four to five feet in width and from fourteen to sixteen feet in length. There were two sprinklers in each pocket, each head thus covering an area of 28 to 40 square feet per head. The following list gives the number of heads on each dry pipe system.

Warehouse No. 2.	South valve (Controlling south half of building)		598
	North valve (Controlling north half of building)		528
Warehouse No. 1.	South pair	North valve — Basement, 1st and 2nd floors .	416
		South valve — 3rd and 4th floors, 288 + 64 (for 44 feet of 6-inch pipe)	352
	North pair	North valve — Basement, 1st and 2nd floors .	484
		South valve — 3rd and 4th floors, 336 + 64 (for 44 feet of 6-inch pipe)	400
Mill	South pair	North valve — Basement to 3rd floor . . .	722
		South valve — 4th to 6th floors, 530 + 82 (for 56 feet of 6-inch pipe)	612
	North pair	North valve — Basement to 3rd floor . . .	672
		South valve — 4th to 6th floors, 516 + 82 (for 56 feet of 6-inch pipe)	598
Dry House . .	One valve only		593
Cleaning Mill . .	North valve — Basement to 3rd floor		342
	South valve — 4th to 6th floors, 231 + 44 (for 68 feet of 4-inch pipe)		275
Elevator "A" . .	South pair	South valve — Basement and 1st floor . .	242
		North valve — Top floors, 227 + 154 (for 105 feet of 6-inch pipe)	381
	North pair	South valve — Basement and 1st floor . .	238
		North valve — Top floors, 210 + 154 (for 105 feet of 6-inch pipe)	364
Boiler House . .	On wet pipe system.		

It will be noted from the above that an excessive number of sprinklers was installed, and that many of the dry valves were badly overloaded. A circuit closer on each dry valve was connected to an electric bell and annunciator situated in the Boiler Room. No hydraulic gongs were provided. Although the system was mainly installed in 1901, the pipe sizes above the dry valves were equal to the 1905 standard.

Standpipes: There were two 2-inch standpipes in the Dry House, with outlets on each floor provided with 1¼-inch linen hose and half-inch nozzles. These standpipes were supplied by a 4-inch underground connection from the 8-inch city main in Quaker Street.

Warehouses No. 1 and No. 2, the Mill, Cleaning Mill and Elevator "A" were provided with 4-inch standpipes and roof hydrants with outlets on each floor and roof, equipped with 2½-inch cotton rubber-lined hose and 1⅛-inch play-pipes. These standpipes were ordinarily dry and were provided with siamese connections at the base for the city fire engine to pump into.

Chemical Extinguishers and Water Pails: A good supply of unapproved chemical extinguishers and bucket tanks were distributed throughout the plant.

Outside Protection.

Private: There were two 2-way hydrants situated to the east of the plant between the Mill and the Otonabee River, and another just west of the concrete weigh scale, all connected to the 8-inch private underground yard main. The fire pump at the north of the Boiler House was provided with four 2½-inch hose connections. A hose house was erected over each hydrant and supplied with 250 feet of 2⅝-inch cotton rubber-lined hose, 2 Underwriters' playpipes and other miscellaneous equipment. Some 450 feet of spare hose and several extra playpipes were kept in the pump house.

Note: Both private and public hydrants are of the frostproof type and not provided with independent gates unless specifically mentioned.

Public: One 2-way hydrant was situated on the south side of Hunter Street directly opposite Warehouse No. 2, another was located approximately 80 feet west of the north end of the Concrete Warehouse, a four-way hydrant, provided with independent gates was situated about 70 feet west of the north end of Elevator "B" and another 2-way hydrant was placed at the northwest corner of Quaker and Murray Streets, approximately 365 feet north of Elevator "A" or 620 feet from the north end of the Concrete Warehouse.

Since the greater portion of Peterboro is situated to the west of the Otonabee River the plant was located on the eastern fringe of the Municipal "gridiron" waterworks system, there being no other source of supply to that portion of the town on the east side of the river than the 8-inch main in Hunter Street. The 8-inch main in Quaker Street was connected to the 5-inch dead end main in Murray Street and to the Hunter Street main just mentioned; the private yard main connected to the Hunter Street and Quaker Street mains forming a loop around the plant.

During the early stages of the fire the three private hydrants previously mentioned and the two public hydrants in Quaker Street at the west of the plant were of practically no use, as there was not enough water pressure for a proper hose stream; and all were absolutely put out of commission when several Municipal gates were shut a short time later in order to raise the City pressure. (*See* "Progress of Fire").

Water Supply.

Private: The automatic sprinklers and private hydrants were supplied by an 8-inch yard main which ran from the 8-inch Hunter Street main along the east side of the plant, turning west just to the north of the Boiler House and after passing under Elevator "A" connected to the 8-inch City main in Quaker Street. This private yard main was valved and checked off at each end. To the west of Elevator "A" an 8-inch branch of the yard main ran south, supplying a 2-way hydrant and the sprinkler system of the Cleaning Mill, and terminated in a dead end opposite the Concrete Warehouse. A connection was made at the dead end of this branch main for the proposed sprinkler system in the Concrete Warehouse. The private pumping supply consisted of a 1,000 gallon (18-inch by 10-inch by 12-inch) steam pump, the steam for which was taken direct from the header connecting the three 150 H.P. boilers in the Boiler House. These boilers were not used for power, but for the fire pump and for manufacturing processes only. A governor, automatic, starting at 65 lbs. was installed on a by-pass around the throttle valve in the steam pipe to the pump. The pump took suction either under a 16-foot head from a 12-inch pipe fed by a 10-inch pipe running to a forebay some 750 feet distant, or by direct 12-foot lift from the Otonabee River through a 12-inch pipe provided with a foot valve and strainer. There were Indicator Post Gates in both suction pipes. Eight-inch check and gate valves were connected direct to the pump discharge, and Indicator Post Gates controlled the underground main just outside the east and west ends of the Pump House. Under normal conditions with this arrangement water could be supplied either to the east or west rows of buildings separately or to both at the same time, and should the underground main be entirely out of commission, four hose lines could be attached direct to the pump.

Public: The supplies to the City hydrants in the vicinity of the risk and to the private hydrants and sprinkler system on the premises consisted of an 8-inch main in Hunter Street supplied by a 10-inch main in George Street some 1200 feet from the plant. This 10-inch main increased to 12 inches approximately 450 feet from George and Hunter Streets and after running for about 3,000 feet connected with 12-inch and 18-inch mains running direct to the City pumping station some 8,000 feet distant. There was a 5-inch main in Murray Street which was connected to the 8-inch main in Hunter Street by the 8-inch main in Quaker Street. This Murray Street main was supplied by two 5-inch connections from the 12-inch main in George Street, which connections were 1900 or 2350 feet distant respectively.

At the Municipal pumping station there were two 3-throw horizontal single acting 18-inch by 30-inch pumps of 2,700,000 U. S. gallons capacity per 24 hours, one 3-throw horizontal single acting 21-inch by 30-inch pump of 3,600,000 U. S. gallons capacity, one 3-stage vertical centrifugal pump of 3,600,000 U. S. gallons capacity and one single-stage centrifugal pump of 7,200,000 U. S. gallons capacity. The 18-inch by 30-inch pumps were each driven by 62-inch

turbines working under a head of from 10 to 11 feet, the 21-inch by 30-inch pump and the smaller centrifugal were driven by 68-inch turbines while the larger centrifugal was driven by a steam turbine. The steam-driven centrifugal was used only at times during the winter months when the ice interfered with the water supply to the other pumps, and on the day of the fire was not in operation. All pumps took suction from the Otonabee River which furnished a practically inexhaustible supply. The regular pressure maintained at the Pump House is 80 lbs. which is raised to 100 lbs. on the receipt of the first fire alarm and is increased to 120 lbs. on receipt of telephone orders from the Chief. The normal water pressure at the Quaker Oats plant, on account of its low location, is approximately the same as that at the pumping station. The average domestic consumption per day for the year ending June, 1916, was 3,832,000 U. S. gallons while the largest amount pumped in any one day under normal conditions was 5,136,000 U. S. gallons.

Fire Brigades.

Peterboro: The public fire brigade comprised a Chief and sixteen men, all fully paid, without other duties and who are in constant attendance at the Fire Hall located 2700 feet from the Quaker Oats plant. The fire fighting apparatus consisted of a 1,000 U. S. gallon steam fire engine, two hose carts, one exercise wagon (used as a spare hose cart) and one hook and ladder truck. The fire department had the following equipment: 5,400 feet of 2½-inch rubber-lined hose and a good supply of playpipes, chemical extinguishers, salvage apparatus and miscellaneous equipment. Fire alarm telegraph system having non-interfering metal boxes, the keys being kept under glass.

Lindsay: In response to a call, a hose truck and company were dispatched from Lindsay some 23 miles distant. While the Peterboro brigade was fighting the Quaker Oats fire, the Lindsay company was stationed at the Fire Hall to answer any other calls and they responded to two such calls during the time they were on duty. Although the threads on the hose couplings belonging to the Lindsay brigade would not fit the Peterboro hydrants, their hose was made serviceable by cutting off the couplings and attaching new ones by means of an hydraulic hose expander kept in reserve for just such emergencies.

Miscellaneous Help: In addition to the two trained brigades the Fire Chief had at his disposal, and accepted the services of several of the police force, a number of the Quaker Oats employees, some ex-firemen and other volunteers. As much hose as could be spared from local manufacturing plants was borrowed and used.

Origin and Progress of the Fire.

On Monday, December the 11th, 1916, about 10.15 a. m., while the plant was in full operation, the odor of burning Vim feed was noticed by some employees in the Dry House. Orders were immediately given by the foreman of the department to shut down the

feed grinders and to locate and extinguish the blaze; but before a sufficient time had elapsed to permit the full execution of these orders, an explosion of terrific violence occurred. The explosion was of such intensity that it blew out the north and east walls of the Dry House, ripped the fire doors off the openings between the Dry House and the Mill and in spite of the fact that these openings were small, had sufficient force to tear off their hinges several small doors at the far end of the 1st and 2nd stories of the Mill, 130 feet distant. At the time of the explosion there were 30 or 40 men at work in and about the Dry House and to them the loss of life was chiefly confined. Many rescues and deeds of almost unbelievable heroism were performed by those who were fortunate enough to escape. The conditions in a Flour Mill are always conducive to the rapid spread of a fire and consequently it was only a few minutes before the whole Mill was enveloped in flames.

In the minute or two that elapsed before the fire completely filled the Mill, some of the employees of the company, under the direction of the superintendent, managed to close the fire doors at the south end of the Mill. Some of these fire doors would not have closed automatically because of the small wooden doors which had been installed to prevent drafts through the elevator shaft and which had been ripped from their hinges by the explosion, as was mentioned before. The rapidity with which the fire spread through the Mill may be judged from the experience of the man who operated the elevator in the tower at the south end of the Mill. One of the standing orders of the plant was that, should the power go off on any occasion, each employee should open the switch controlling the motor of which he was in charge. This elevator was in one of the upper stories and, following his instructions, the operator ran up to the pent house to shut down his motor, but before he could return to his elevator the shaft was so full of smoke that his only way of escape was through one of the upper windows overlooking the roof of Warehouse No. 1. He climbed out of the window and as the smoke became more dense he was forced to hang from a hinge imbedded in the brickwork for a proposed fire shutter, until the firemen rescued him.

When the north wall of the Dry House fell, it crashed through the roof of the Boiler House and broke all steam connections from the boilers, thus putting the fire pump out of commission. As the east wall fell it took with it a 6-inch sprinkler riser and buried the indicator post gate valve controlling this riser, which valve was located 26 feet distant from the walls of the building. Deprived of the assistance of the fire pump, with the 6-inch riser broken off, and with the great excess of sprinklers in the lower floors of the mill, being fused by the first blast of flame, the street mains leading to the plant were utterly inadequate to maintain any pressure against such a draft; nor could it ever have been anticipated that they would be subjected to such a demand.

There was a moderate wind blowing from the northeast which drove the fire slightly out of the line of the Cleaning Mill, and for a

Fig. 4. Shows collapse of grain tank and dry house; also fire gaining headway in frame metal clad grain elevator.

Fig. 5. Photo taken shortly after Fig. 4 above.

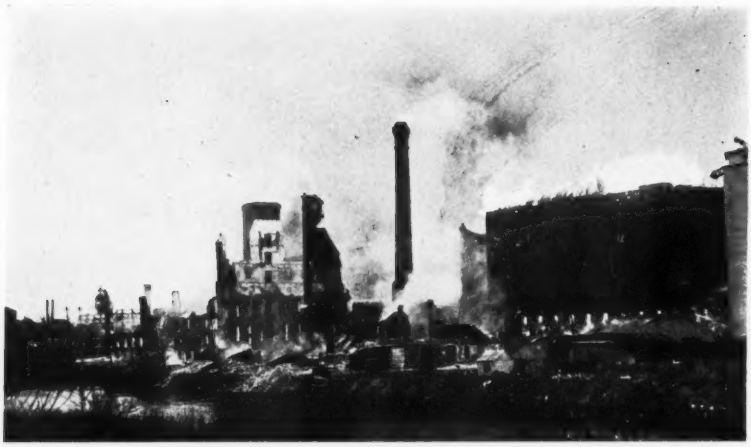


Fig. 6. Photograph taken at noon. Illustrates rapidity of fire.

time it was hoped that fire would not reach it. But when the west wall of the Dry House collapsed, the exposure was too great and the Cleaning Mill began to blaze. From there it worked through the fire doors above and below the grain bins into Elevator "A".

At the fire wall between the Mill and Warehouse No. 1 there were no door openings in the 2nd, 3rd and 4th stories, except through the elevator tower, owing to the difference in floor levels, and as the openings into this tower from both Mill and Warehouse were equipped with fire doors, it afforded a double barrier to the progress of the fire. As may be seen from Figures 4 and 5, fire did not enter Warehouse No. 1 until the Mill was practically gutted, and then probably due to the fact that falling walls or floors tore the fire doors from their fastenings. During the time that the fire was held up at this point, some of the office employees began to remove fixtures and records to a place of safety. Some thought that they were premature in their action, but when the fire got into Warehouse No. 1, it travelled through this building and Warehouse No. 2 with such rapidity that had not the records already been saved, they never could have been.

The fire spread rapidly from Warehouse No. 1 to Warehouse No. 2, for in the 2nd story were two large unprotected dryer openings (18 inches by 48 inches) and only single fire doors at all other openings.

Figure 6 taken at noon shows how rapidly the plant was reduced to ruins, although Elevator "A", because of its wooden crib construction, continued to stand and burn for some time until it finally collapsed. The burning grain was heaped against the south end of Elevator "B" and the concrete was considerably spalled; but beyond this the Elevator suffered no material damage at this time. Some six weeks afterwards, however, as a result of the corn in the

south bins of Elevator "B" being heated and generating a large quantity of gas, there was an explosion, which blew off the roof of the southeast bin and made a small hole in the side wall but did no further damage. The Concrete Warehouse which was located to the west of the Mill is obscured from view in this picture by the smoke. It was still standing, however, although fire had entered it about half an hour previously.

From the very start of the fire, the Concrete Warehouse was subjected to a terrific exposure from the burning Mill and Warehouses, but although the windows were not equipped with shutters, it was not until about the time of the collapse of the other buildings that fire entered—as may be seen in Fig. 7. The fire first gained admittance through an open window ventilator near the north end of the 4th floor at about 11.30 a. m. Owing to the radiation of heat through the wired glass windows, numerous other blazes followed almost immediately and in a few minutes the fire had spread throughout the whole building.

At the time of the fire the Concrete Warehouse was heavily loaded on all floors but the fifth, with a great quantity of combustible material which, fanned by the wind from the east, burned with all the fierceness of a coke fire until 6.00 p. m., when practically all that portion north of the elevator shaft suddenly collapsed. The loosen-

Fig. 7. Shows how concrete warehouse, equipped with wired glass windows, withstood exposure until other buildings collapsed.

Fig. 8. View looking North from Hunter Street. Note stock piled high in concrete warehouse. Ruins of mill buildings on right.

ing up of the combustible material, while falling, greatly augmented the heat, and flames shot up for hundreds of feet into the air. The heat liberated by the collapse drove the spectators blocks away from the place and it was only by a most strenuous effort on the part of the Fire Department that a general conflagration of the city was avoided. After the collapse, the fire continued to rage until everything combustible was entirely consumed; even the ashes being fused on the second floor of the part still standing. In the collapsed portion the fire continued to burn for more than two months afterwards.

How the Fire was Fought.

The noise of the explosion in the Dry House was distinctly heard at the Fire Hall and the firemen who knew that something had happened immediately hitched their teams and as soon as the alarm came in, simultaneously by telephone and fire signal, were on their way to the scene of the fire. When they arrived, they found the officials and employees of the Quaker Oats Co. working desperately in an effort to get the girls who were working in the Package Department in the 2nd story of Warehouse No. 1, out of the building, to close all accessible fire doors and to rescue the men who were known to have been working in the Dry House, many of whom could be seen en-

veloped in the flames and endeavoring to escape. This rescue work took considerable time at the start, which would have been valuable had the water pressure been up to normal, and it is to the credit of all concerned that the emphasis was laid first on the saving of life. While some members of the brigade were attending to the injured, others attached hose lines to the hydrants in the immediate vicinity; when it was first found that there was no available pressure. With the east wall of the Dry House down and knowing that a sprinkler riser was located there, the cause of the low pressure was beyond question. The Waterworks Superintendent, who was in his office at the time of the explosion, heard the report and rushing out saw the dense cloud of smoke in the direction of the Quaker Oats plant and on looking at his pressure gauge noticed that the water pressure had dropped very low. He immediately telephoned to the pumping station for 100 lbs. pressure and taking several waterworks employees with him, went to the fire in a Corporation motor truck. Upon his arrival at the plant, he found there was no pressure and after ascertaining the cause, shut the valve in the Hunter Street end of the yard main in order to try and improve the pressure. He then consulted with the Superintendent and the Fire Chief as to the advisability of shutting off the valve in the yard main just west of Elevator "A." They concluded that for a time at least it would be well to leave this valve open as there might be a chance of the sprinklers doing some good. After waiting a short time and seeing that the whole east row of buildings was doomed, and that the pressure had not improved, he decided on his own responsibility to close this second valve, but owing to new construction work was unable to locate it. With the help of some of the waterworks employees he thereupon closed the valves at both ends of the Quaker Street main, which, although it cut off completely the water supply to the plant, at once improved the general pressure and made it possible to prevent the spread of the fire to adjacent property. It will be noted from Plate I that there was a valve in the yard main on each side of the Pump house. If, instead of shutting off the entire Quaker Street main, either one of these valves had been closed in addition to the valve near the Hunter Street end, the broken sprinkler riser would have been isolated and at the same time full city pressure would have been made available for the sprinkler systems in the Cleaning Mill and Elevator "A", as well as for the three hydrants on Quaker Street. That it would have been possible to have reached either of these valves near the Pump House may be inferred from the testimony of a witness in the investigation conducted by Provincial Fire Marshal Heaton, in which it was stated that right after the explosion the witness ran back to the Boiler Room where he knew several men were working, broke a window and crawled in to see if he could find any trace of these men. Figure 6 shows that even after the Cleaning Mill and Elevator "A" were a total wreck these valves were still available.

However, owing to the extreme severity of the fire, it is doubtful whether the sprinkler systems in the Cleaning Mill and Elevator "A"

Fig. 9. Shows ruins of Dry House and other buildings.

could have prevented the fire from entering, in which case it would soon have been necessary to cut off the Quaker Street main.

During the period of low pressure, fire started among some of the box shooks in the 4th story of the Concrete Warehouse and an attempt was made to extinguish it. A line of hose was carried through the front door and up the stairs but had to be abandoned because of lack of water. So rapidly did the fire spread through the Warehouse that several of the men who had taken in the hose barely managed to escape. When the pressure came back to normal, the fire had reached such proportions that it was realized that to try and save the plant was useless. From this time on all efforts were directed to the saving of surrounding property and with this end in view fifteen or more lines of hose were laid from all the hydrants in the neighborhood.

Thus it will be seen that from start to finish the fire was allowed to burn unrestricted. But in spite of the best efforts of the firemen, when the wood crib elevator collapsed, flying brands set fire to the roof of the Court House. Before they could disconnect their long lines of hose and bring their streams to play upon the Court House, the roof was burned off. When the Concrete Warehouse collapsed, such a quantity of burning material was carried by the wind that the firemen had to redouble their efforts in putting out scores of little blazes. As soon as it was seen that the danger of a general conflagration of the town was past, the Lindsay brigade was allowed to return home and as soon as conditions would permit, that part of the plant in which bodies were supposed to be buried, was deluged with water, and all available help was set to work to try and locate the missing.

Discussion of Possible Causes of the Explosion.

The question of the possible cause of the explosion presents a subject worthy of most careful consideration. It will be noted from the diagrammatic sketch Plate IV that the processes of drying the green oats involved the use of the direct products of combustion of coke. The gas from the burning coke after passing from the inner perforated tube of the kiln through the oats filled the entire enclosed space in which the kilns were located and drifted upwards through two large flues to the roof. It is said that only those accustomed to doing so, could go into the kiln room because of the gases, and it is certain that there must have been considerable quantities of carbon monoxide there. When mixed with air in the proportions of between 13 and 75% of carbon monoxide the mixture is explosive and human beings can exist in an atmosphere in which as much as 5% of carbon monoxide is present. There is the possibility of a mixture richer than 5% being formed on the occasion of fresh firing and there is also the possibility of "water gas" being formed near the upper part of the kiln room from the mixture of the carbon monoxide with the steam from the humidifying device located at the point where the oats entered the dryer. It is therefore possible that there could have been an explosive mixture in this room. As an evidence that the

Fig. 10. Column examined to ascertain depth of dehydration. (See page 410)

explosion might have occurred here, it may be pointed out that the direction of the blast was such that it could have originated here; the floors of the Mill on the opposite side of the division wall bracing this wall against failure.

The distribution of the debris shows that the north and east walls were pushed out near the bottom, which could only have occurred with an explosion in the lower part of the building. Had the explosion occurred either in the basement or top story, the fire would have been blown into the Cleaning Mill at once through the tunnel or the bridge, but we know that for some time it was hoped to save this building. It can be seen therefore, that there is a possibility of the explosion being due to the free gas process of drying the grain.

Fig. 11. Column which had been thickened by pouring of additional concrete. **(See page 410)**

The only other plausible explanation is that there was some form of dust explosion. Slight explosions or "puffs", as the men called them, were of common occurrence and attracted no more attention than was required to locate the smouldering material that had been scattered about and extinguish it. The management appreciated the danger incidental to dust explosions and, to avoid the possibility of one, connected a fan to the attrition grinders to reduce the accumulation of dust to a minimum. This fan exhausted into a dust bin located on the roof of the Boiler House. Since small explosions sometimes occurred in this dust bin, the sides were hung on hinges

so that at no time would there be any danger of such an explosion flashing back into the Dry House.

The seat of most of the "puffs" was located in the attrition grinders and when such a puff occurred it was in the grinders that the trouble was first sought. Although the oat hulls before reaching the grinders had passed through magnetic separators, aspirators and other cleaning devices, foreign substances sometimes reached the grinders and caused the sparks which set the ground hulls on fire. Often the first indication that there was any fire in the grinder would be the pungent smell of burning hulls.

These attrition grinders, with the exception of one that was belt driven and which was not in use on the day of the fire, were individual induction motor driven and had outside ball bearings.

On one occasion such a "puff" spread the fire through an elevator leg into a ground hull tank where a more violent explosion ensued, sufficiently powerful to lift the roof about two feet into the air. The roof then dropped back into place.

Dust has always been recognized as dangerous from the explosion standpoint, but with the development of modern dust collecting machinery, dust explosions in flour mills have largely been eliminated and are now chiefly confined to mills handling grain other than wheat.

The table on page 407, taken from a pamphlet entitled "The Explosibility of Grain Dusts" prepared by "The Millers' Committee of Buffalo, N. Y.," shows conclusively the real and terrible danger from dust explosions.

It is not possible to tell from this table whether drying operations were carried on at the above plants in a manner similar to that used at Peterboro, but it will be seen that explosions Nos. 1, 5, 8, 9, 10 and 11 were probably caused by sparks in grinding machines. In at least three of these instances the grinding machines mentioned were attrition mills, and it is probable that they were in the other cases also. In explosions Nos. 2, 12 and 13, neither drying nor grinding operations were carried on, so that it would appear that in the dust itself lies the cause of the explosion, sparks only being necessary to ignite it, whether from naked lights, static electricity from belts, friction, or other local causes.

The attrition grinders which appear to have furnished the spark needed in so many of the foregoing explosions and which we know caused most of the "puffs" at the Peterboro plant, appear also to have been responsible for the ignition of the explosive mixture in the atmosphere of the Dry House on December 11th.

As stated in the testimony taken before Fire Marshal Heaton, one of the employees working on the upper floor of the Dry House smelled smoke, and went down stairs and notified the foreman of the department, who immediately sent his assistant to see if the fire could be in the elevator boot into which the grinding machine discharged, while he himself went to the grinding floor and shut off the grinders and "opened up the cover and saw fire." These few words muttered in the hospital before he died prove conclusively that it was

GRAIN DUST EXPLOSIONS IN UNITED STATES SINCE 1905

Date	Location	Nature of Business	Nature of Occurrence	Supposed Cause	Number Killed	Number Injured	Property Damage	Extent of Damage
Mar. 5, 1905	Iowa	Cereal mill	Fire following explosion	Sparks from grind-machine	2	3	$1,000,000	Nearly complete
Oct. 7, 1908	Vermont	Elevator	Explosion	Unknown	17	3	139,000	Complete
Jan. 4, 1910	Western New York	Cereal Mill	Explosion	Unknown	5	7	118,000	Partial
Mar. 7, 1910	Indiana	Starch factory	Explosion and Fire	Unknown	4	10	30,000	Partial
Aug. 7, 1910	Illinois	Glucose factory	Explosion	Sparks from grind-machine	2	7	40,000	Partial in elevator building
Nov. 25, 1912	Illinois	Starch factory	Explosion	Unknown	14	19	100,000	Partial
June 25, 1913	Western New York	Feed mill	Explosion and Fire	Unknown	33	60	465,428	Partial
Sept. 11, 1913	Iowa	Cereal mill	Explosion and Fire	Sparks from grind-machine	—	—	42,500	
Sept. 12, 1913	Western New York	Feed mill	Inflammation	Sparks from grind-machine	1	7	180,000	Partial
Nov. 1, 1913	Kansas	Flour mill	Explosion	Sparks from grind-machine	—	—	Not exc. 100	Slight explosion; confined to limited area
Nov. 6, 1913	Iowa	Cereal mill	Explosion	Sparks from grind-machine	3	—	1,200	Partial
Dec. 2, 1913	Ohio	Elevator	Explosion	Unknown	—	—	Slight	Partial
Mar. 30, 1914	Texas	Grain Elevator	Explosion	Unknown	—	—	6,500	Partial: valuation $250,000

Fig. 12. A column failure.

in the grinders that the fire which caused the explosion originated. The assistant ran to the floor below, taking a chemical extinguisher with him, and just as he opened a small slide in the elevator leg the explosion occurred. From this it would appear that the opening of one or both of these covers admitted enough air to permit the smouldering ground feed to burst into a blaze which ignited the explosive material in the air. It is very likely that the coke gas in the kiln room did not cause the explosion, although it may have added greatly to its intensity.

The first explanation offered for an explosion of this intensity was that it must have occurred in one or more of the ground oat hull tanks located near the top of the building, into which the elevator leading from the attrition grinder discharged, but owing to the facts that all but one of these tanks remained standing for some little time after the explosion, that the walls appeared to have been blown out near the bottom and that fire was not driven across the bridge to the Cleaning Mill, it is evident that the explosion must have taken place in the lower floors of the building where both the attrition grinders and kilns were located.

Damage to Buildings.

Owing to the direction of the wind, the Pump House was damaged but little, part of the roof being smashed. The Boiler House roof was crushed and the boilers put out of commission when the north wall of the Dry House fell. This was the extent of the damage until the Dry House floors and tanks collapsed at 10.50 a. m., as shown in Figure 4, which completed the ruin of the building. Curiously enough the smoke stack survived. Throughout the re-

Fig. 13. A column which forced its way through ceiling.

maining buildings in this row the ruin was complete. As is graphically shown in Figure 9 nothing but hopelessly tangled masses of machinery and a few stumps of walls are left. Beyond the spalling of the lower 15 feet of the three south bins of Concrete Elevator "B," this was scarcely damaged, which may be largely attributed to the direction of the wind. Elevator "A" and the Cleaning Mill were as completely ruined as the Mill, the only things of a combustible nature that were left being a large quantity of grain which was partly salvaged during the next couple of months, before burning completely through, and the bottoms of some wooden columns that were buried in this grain.

The Concrete Warehouse after standing for over six hours, with a fire of almost unparalleled intensity on all floors simultaneously, suddenly collapsed to the extent of six and two-thirds bays north of

the elevator. In the remaining standing portions destruction is practically complete and if not razed before long these portions will collapse of themselves; progressive disintegration is rapidly going on. In these standing portions lessons of great value as to the fire-resisting qualities of different materials and appliances may be learned. From their appearance in the photographs, the columns do not seem to have sustained much damage, but upon examination it was found that the surface of the concrete had been calcined to a depth of from half an inch to an inch and beyond this, dehydration of the cement extended inward to an undetermined distance. In an endeavor to ascertain the exact depth of this dehydration, the concrete on one column was removed until the reinforcement was reached when two of the spiral bands were cut. Upon proceeding to cut one of the longitudinal rods with a hack saw, it suddenly pulled apart when the saw had cut only about two-thirds the way through, indicating that stresses of unknown magnitude existed. Although a depth of 5 inches from the surface had been reached and sound concrete not yet discovered, it was considered advisable to abandon any further effort. This column is shown in Figure 10 where a pencil may be seen in the saw cut mentioned.

In the third and fourth stories, where the original columns had been thickened by pouring an additional 2 inches of concrete around them, the difference in damage is quite marked. Beneath this 2-inch coat the concrete of the original column appeared to be in a better condition than in those columns that were entirely exposed to the fire. One of these is shown in Figure 11. On account of the condition of the building it was unsafe to ascertain the exact condition of these columns.

There is no doubt, however, as to the condition of the floors for they sagged in practically every panel as may be seen in Figures 14 and 15. Here, as in the columns, all surfaces have been calcined and large patches of the ceiling surface have fallen to the floor and crumbled into heaps of air-slacked lime. Upon examination of the concrete in numerous places on all stories, the floors were found to have been dehydrated completely through. This is entirely at variance with the experiences of the "Edison Fire" where it was found that the concrete was seldom injured more than an inch and a half to two inches in depth except at the corners where it was first thrown off by expansion of the concrete and later by the reinforcing bars. It is also at variance with the experience at the "Far Rockaway Fire" where a quartz aggregate caused serious disintegration of the concrete.

On removing some of the concrete from the slab rods it was found that although in some cases there was but half an inch of fireproofing between the surface of the rod and surface of the slab, there was no sign of oxidation.

The testimony taken before Fire Marshal Heaton shows that the bulk of the stock was piled to the north of the elevator on all floors, and it has been shown that in many places the actual floor loads were in excess of the designed live loads. With the reduction in strength of the floors, due to the long sustained heat and with such

Figs. 14 and 15. Sagging of floors.

loads upon them, it is surprising that the building did not collapse long before it did. The standing portions of the building show that the floors must have failed first and thus caused the collapse of the building. The wall panels in the standing portion sag much more than do the centre panels. This is probably due to the fact that a ten-foot trucking space was reserved down the centre of the building.

During the afternoon there were a number of minor explosions in the piles of blazing material in this building, which in one or two

Fig. 16. Corrugated steel doors in elevator shaft. Note also condition of wood tin-clad trap at stair opening on left,

places damaged the weakened floors. Evidence of one such explosion is shown in Figure 16, where the broken concrete may be seen around the opening instead of having dropped to the floor below.

With the terrific exposure to which they were subjected the wired glass windows withstood the fire remarkably well and it was largely due to radiation of heat through them rather than to their failure that the fire gained admittance to the building. The metal frames, both hollow and solid, gave an excellent demonstration of their value.

It is interesting to compare the condition of the wood tin-clad fire doors in Figure 17 with the corrugated steel doors in Figure 16 which were on different floors in the same shaft and probably had to withstand about the same temperature. The remains of a wood tin-clad trap door can be seen near the centre of Figure 16. On all other floors these traps were in the same or even worse condition.

Temperatures Developed During the Fire.

There was such a volume of fire throughout the entire plant at the same time that exceedingly high temperatures were developed, which were not confined to isolated spots, but existed throughout the buildings and in numerous places outside. Outside the buildings there were a number of box cars on the different sidings—nothing is left but the metal parts of these cars and in several instances the chilled iron wheels were melted and in one case at least the wheel and the rail upon which it was standing were melted together. In clearing up the ruins of the Dry House much difficulty was encountered because of the fact that structural steel beams, columns and tanks were fused into one mass. In the Mill and Warehouses No. 1

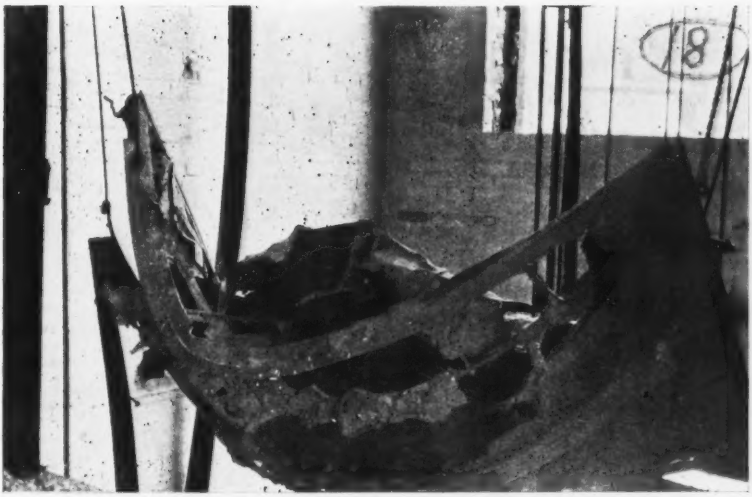


Fig. 17. Wood tin-clad fire door in elevator shaft.

and No. 2, many melted pieces of cast iron were found that were originally machine frames. On all the standing walls there are large patches of melted brick work. In Elevator "A" and the Cleaning Mill practically all the visible inside area was affected in this manner. Figure 18, showing a portion of the elevator shaft in the Concrete Warehouse, gives an excellent illustration of this condition and Figure 19 shows one place in the Concrete Warehouse where the brick was melted to a depth of over 4½ inches. This was not because of the inferior quality of the brick, for in all buildings, well-made machine-moulded clay brick was used. In the second and third story windows of the Concrete Warehouse, quite a number of completely melted cast-iron sash weights were found, while in other places in this building the heat was so intense that the ash from the burned cereals was melted into a phosphatic glass. Some of this material may be seen hanging from the ceiling in Figure 15. The roof drain which ran about two-thirds the length of the building was expanded by the heat and on cooling contracted, leaving the swing joint connection as an evidence of the amount of expansion.

On account of concrete having fused at the "Edison Fire," particular care was taken to see if any of the concrete had fused here, but nowhere throughout the plant was there evidence of fusion having occurred. The only effect of the heat on the limestone aggregate was to calcine those stones near the surface.

The complete dehydration of the 9-inch floor slabs together with the other items just mentioned proves that the fire at the Quaker Oats plant was of at least equal intensity and of far longer duration than the fire at the Edison plant.

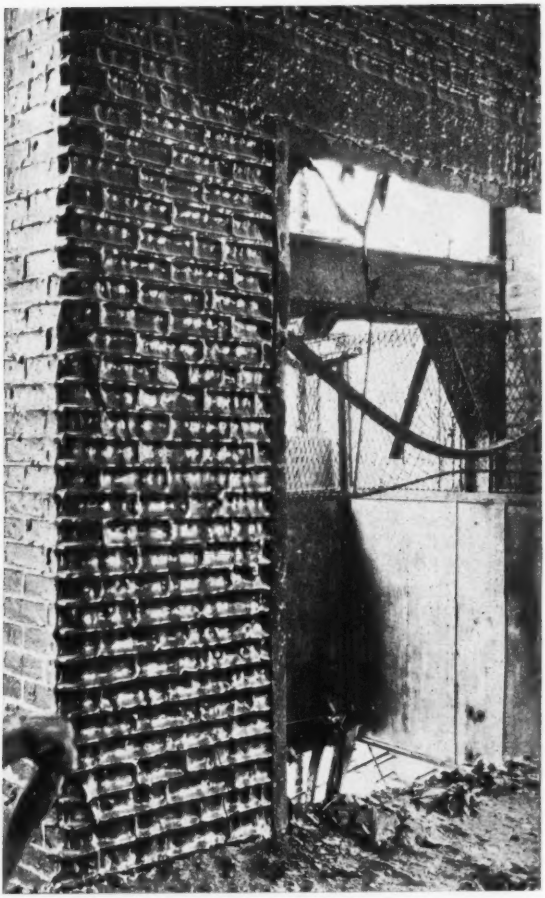


Fig. 18. Melted brickwork at an elevator shaft.

Property Loss.

Accurate figures as to the value of the property at the time of the fire and salvage are not available at the present time. Roughly speaking, however, it may be stated that at the time of the fire the plant was worth approximately $2,250,000. The concrete grain bins and their contents are practically uninjured and there was partial salvage of grain from Elevator "A," but the remainder of the plant is a total loss.

Loss of Life.

The most tragic feature of the conflagration was the appalling loss of life. Owing to the open gratings in the floors of the Dry House the explosion blew the fire into all stories, enveloping the

Fig. 19. Melted brickwork in concrete warehouse.

workmen in flames. Some of these men were able to make their own way out and even to assist in the rescue of the less fortunate ones. All the men in the Boiler House were killed when the north wall of the Dry House crashed through the roof. A car checker who was just outside the Boiler House was caught by the falling wall. One man who was wheeling coke was buried by the falling east wall. Of the thirty men who were taken to the hospital, twelve died of their injuries. These twelve together with the four in the Boiler House, the two killed outside and four missing make a total of 22 fatalities. Of those taken to the hospital and who recovered many are maimed for life.

It is a fortunate thing that there were stairways at the south ends of both warehouses, for if the more than two hundred girls at

work in the package department had been obliged to depend on the stairway in the elevator tower, loss of life would have undoubtedly been much larger; or if the fire had occurred at night the panic that would have ensued when the power went off and lights went out, might have resulted in a much larger loss of life.

Lessons of the Fire.

Once again the importance of isolating hazardous processes is emphasized and it is suggested in order to secure a minimum damage from any possible explosion, a means for the explosion to vent itself be provided either by making the exterior walls of light curtain wall construction or providing large plain glass areas. It would seem advisable also to locate control valves at a safe distance from the buildings where such hazardous processes are carried on.

If in any way it can be ascertained that the coke gases in the Dry Kiln Room contributed to the intensity of the explosion, such methods of grain drying should be abandoned and some safer method such as steam drying adopted.

The complete failure of the Concrete Building shows the necessity of providing automatic sprinkler protection wherever the contents of a building are combustible, irrespective of the construction of the building; and the folly of constructing an otherwise fire-resistive building and then leaving large unprotected openings, such as the bag hoist openings in the Concrete Warehouse, is demonstrated.

The value of being prepared to utilize the equipment of a neighboring Fire Department even though the hose couplings had different threads is demonstrated by the way in which Peterboro was enabled to use the services of the Lindsay Fire Brigade.

Acknowledgment.

This report was made possible through the courtesy and cheerful co-operation of the Quaker Oats Company local officials; W. A. Howard, Fire Chief of Peterboro; Ross Dobbin, Waterworks Superintendent of Peterboro; Provincial Fire Marshal E. P. Heaton; E. H. Sigison, Manager, Buffalo Association of Fire Underwriters; David J. Price, Engineer, U. S. Bureau of Agriculture; Prof. I. H. Woolson, Consulting Engineer, National Board of Fire Underwriters; W. W. Pearse, City Architect, City of Toronto and T. D. Mylrea, Engineer of Tests, City Architect's Department, City of Toronto. The Quaker Oats Co. local officials gave permission to examine the ruins and with Fire Chief Howard and Waterworks Superintendent Dobbin answered various inquiries. Provincial Fire Marshal E. P. Heaton allowed our representatives to study the various exhibits filed with him at the time of the investigation. Mr. E. H. Sigison and David J. Price forwarded bulletins on the "Explosibility of Grain Dusts," Prof. Woolson took the trouble to ask a series of suggestive questions, the answering of which would tend to bring out many points of interest. W. W. Pearse granted permission to incorporate in the report a cut of the Concrete Warehouse and numerous photos taken by Mr. T. D. Mylrea who gave much valuable information, especially in connection with the Concrete Building.

Department of Fire Record.

Four Instructive Hotel Fires.

H-12041. This fire, involving the loss of six lives, originated in the low dark basement of a thirty-year-old tenement house which was occupied as a second-class hotel. The building was of brick and timber, and at the time of its erection had been considered one of the finest residences of its type. It was a three-story and basement structure, the basement being on or near the street level. Some years ago its use for private residences was abandoned and it became a rooming house. Later it was converted into what may be called a second-class hotel. In more recent years the property had greatly deteriorated, and at the time of the disaster rooms only were rented, the roomers having some arrangement for light housekeeping. The basement was occupied for mercantile purposes, including a few offices, a delicatessen and a tailor shop.

Fire was discovered in the rear of the basement between 11 and 11.30 p. m., on a bitterly cold winter night. Owing to the age and construction of the building the flames spread rapidly, and there was some delay in turning in an alarm. When the alarm did reach the fire department, the company that ordinarily would take charge of a fire at the location of the hotel was at work at another fire several blocks distant. This other fire also was a serious affair, and every company reporting was busy, all having laid lines. For this reason there was still further delay in the arrival of apparatus. The first company to arrive had no ladders, although the flames had already spread through the building and people were jumping from the windows. The salvage corps which appeared on the scene almost simultaneously with the first fire company used their covers as life nets, and two or three minutes later a truck with ladders became available. The firemen were able to save a number of people from the second and third floor windows, but six were burned or killed in jumping. A 3-11 alarm was sounded immediately on the arrival of the first company and the fire was soon under control. The building, however, was gutted and the walls so weakened that they were ordered to be taken down.

The burned hotel severely exposed a three-story brick building, but no damage was done and the fire did not spread, **except that**

burning embers set fire to the roof of a frame house a hundred feet away. Fortunately this roof fire was quickly extinguished.

Several people have claimed that they telephoned in the alarm, but records indicate that the first alarm was received at headquarters by telephone from a street car conductor whose car was due at that corner at 11.36 p. m. The nearest company was twenty-four blocks distant and was compelled to drive to the fire by a round-about route, owing to the condition of the streets. Other companies also were dispatched to the scene and arrived within a very few minutes of the first company.

The firemen handled the fire with all possible promptitude as soon as they were notified, but in the circumstances the building was doomed.

It is to be hoped that the agitation which has been started locally in favor of an ordinance rendering sprinkler equipment compulsory in buildings of this type of construction and occupancy will not be allowed to die down until its object has been accomplished, and that other cities permitting similar conditions will learn their lesson without waiting for a similar waste of life within their own borders.

H-12071. The hotel in which this fire occurred is of a very different type from that described in the preceding note. It is a basement and eleven-story building of fire-resistive construction, 90 feet by 145 feet in area. As indicated in the plan, the structure above the ground floor is U-shaped.

Construction.

The walls are of brick, with stone and terra cotta trimmings, the floors and roof are of flat arch construction of semi-porous 8-inch hollow terra cotta blocks carried by structural steel beams and steel columns. The finished floors are of 1-inch board. The floors were mostly carpeted, nailed to screeds imbedded in cinder fill. Columns are protected by terra cotta about 2 inches thick and metal lath and plaster, and the lower flanges of beams by terra cotta nearly an inch in thickness. All partitions are of hollow terra cotta blocks about 3 inches thick, laid in cement mortar. Walls and ceilings are plaster finish, and the walls are all papered. The interior trim is of wood, the doors of heavy wood and paneled. There are no transoms over the doors. The wooden picture moulding in corridors is several inches deep, being large enough to conceal the telephone wires.

The main stairs are located next to the passenger elevator at the right-hand angle of the "U," and are of iron and marble with an iron balustrade, the only woodwork being the wooden handrail and *the dado moulding, from 4 to 5 inches wide, on the wall.* The passenger elevator well is tile-lined on three sides, the front being iron grille-work open on each floor. The service stairs and elevator well, which were used by such of the guests as could reach them on the night of the fire, are situated at the left-hand angle of the "U," and are well cut off in a brick well.

Story of the Fire.

The fire occurred between 4.30 and 5 a. m. and is attributed to careless smoking. The occupant of Room 21 on the third floor lighted a cigarette and went to his bathroom. On his return he found his bed on fire. The window of the room was open, and a strong wind which was blowing at the time from the northwest apparently fanned the flame. The outside temperature was about 10° F. Unable to put the fire out by himself, the guest rushed down to the office to secure the assistance of the clerk and telephone operator, leaving his door open in his haste. The efforts of the clerk and operator also proving unsuccessful, the latter ran back to the

Typical Floor Plan, 2nd to 10th inclusive.

office and telephoned an alarm. The fire department has no record of the receipt of this alarm and no apparatus was sent in response to it. This was at about 4.53 a. m. At 4.59 a. m. an outsider saw the flames and turned in an alarm, and four subsequent alarms were necessary, the last being given at 5.27 a. m. The reason for so large a number of alarms is that men and ladders were needed to save life. This fact was probably also a factor in the spread of the fire, as the firemen were not only busy in the work of rescue, but the service stairs and elevator were in use by fleeing guests with consequent hindrance to the work of laying hose lines.

The fire rose from floor to floor in a remarkable manner by means of the main stairs and the passenger well, which it reached from the right-hand corridor along which the flames were driven by the wind.

There was little combustible material in the elevator and stair wells, but the fire seems to have spread from heat as much as from

flames. The woodwork had a fairly heavy varnish finish which evidently burned readily, blistering where the heat was moderate, and bursting into flame and charring where the heat was more intense.

Extent of the damage.

The third-floor room in which the fire started was completely gutted, and practically all the woodwork in the path of the fire along the corridor to the stair and elevator wells was destroyed. Fortunately none of the doors was open, and as there were no transoms and the charred doors held in place, the fire did not communicate to any of the rooms. On this floor, as on the fourth and fifth floors, the fire did not spread more than half-way along the corridor leading from the main stairway to the service stairway. On the fourth floor the room directly above the point of origin of the fire shows a slight amount of burning at the head of the window, where the fire partially succeeded in gaining entrance from outside. The elevator grille-work also on the fourth floor is somewhat distorted as a result of the heat. On the sixth floor the corridor was completely gutted its entire length, and most of the plaster finish has fallen, but only three rooms were entered. The fire practically skipped the seventh, eighth and ninth floors, the only damage on those floors being a little blistering and charring of the woodwork opposite the elevator front. Three or four rooms were badly damaged on the eleventh floor, and at the head of the window of one of these rooms occurred practically the only damage to the exterior of the building, the stone trim being badly spalled and the metal cornice above showing some damage. Beyond this the building was apparently not injured structurally, the damage being confined to finish and contents.

The loss is estimated at $50,000.

Lessons of the Fire.

The principal lesson of the fire is that even in buildings of the best construction it is of vital importance to have stairs, elevator wells and indeed all floor openings enclosed in a standard manner. That there was no loss of life in this fire seems to have been more a matter of good fortune than anything else.

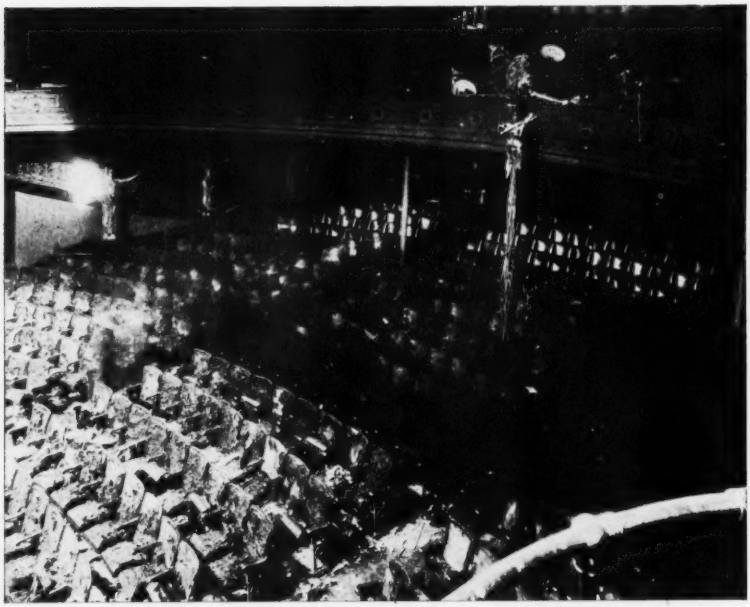
Incidentally it is of interest to note that the only rooms damaged were those where the doors were open. The absence of transoms was undoubtedly a factor in restricting the loss, as open transoms, had there been any, would probably have had the same effect as open doors in spreading the fire.

H-12134
H-12170

These two fires occurred within a couple of days of each other in different hotels in the same large city on the Pacific Coast. According to the testimony of the Fire Chief, if they had occurred simultaneously the entire business section of the city would probably have been destroyed. In both cases the point of origin was the basement; in both cases the building was an ordinary joisted brick structure; in both cases the first floor and

basement were occupied for purposes involving special hazards, the fire being attributed in one case to spontaneous combustion in a stock of fertilizers stored in the basement and in the other to ignition of gasoline vapor by static electricity on human hair which was being cleaned with gasoline in the basement. **Hotel basements are not suitable locations either for the storage of fertilizers or for the cleaning of hair with gasoline.** The fertilizer fire, which drove some hundreds of scantily-clad persons into the street occurred at about 3 a. m.; the hair cleaning fire fortunately happened at a later hour—between 8 and 9 a. m. In the former case, the hotel comprised two adjoining and communicating structures, one of which was a fire-resistive building of steel frame construction. The communications were protected by fire doors and there was a fire wall in the basement. Notwithstanding this protection, every available piece of fire-fighting apparatus in the down-town districts was needed to get the fire under control. The loss was estimated at $45,000. In the basement which was set afire by the hair-cleaning there were no fire walls although the building covered an area of no less than 25,000 square feet and was three stories in height above the basement. Under such conditions the fire was an extremely difficult one to handle, and it burned out nine establishments in the central portion of the building on the first floor before it could be extinguished. The loss was stated to be $125,000.

In this city an active and progressive fire chief has long—and hitherto vainly—been striving to secure the adoption of ordinances which will involve either the improvement or the destruction of existing fire-traps. Besides demanding power to require the building of necessary fire walls and the installation of automatic sprinklers in basements, the chief has also complained of inadequacy in the equipment of his department.



View from stage showing damage to upholstered chairs. The large chandelier supported at roof is shown where it fell on first balcony.

Willis Wood Theatre Fire, Kansas City.

Special Report by Missouri Inspection Bureau.

Construction.

The Willis Wood Theatre, situate at the corner of Eleventh Street and Baltimore Avenue, was a building of fire-resistive construction, equal to five stories in height, with basement, 100 feet by 140 feet in area. All walls were of brick, stone, and terra cotta, 16 inches at the top, 24 inches at the bottom. The floor and roof of the auditorium were of reinforced concrete, the stage floor of wood, the loft floors and roof of reinforced concrete on unprotected steel.

Occupancy and Housekeeping.

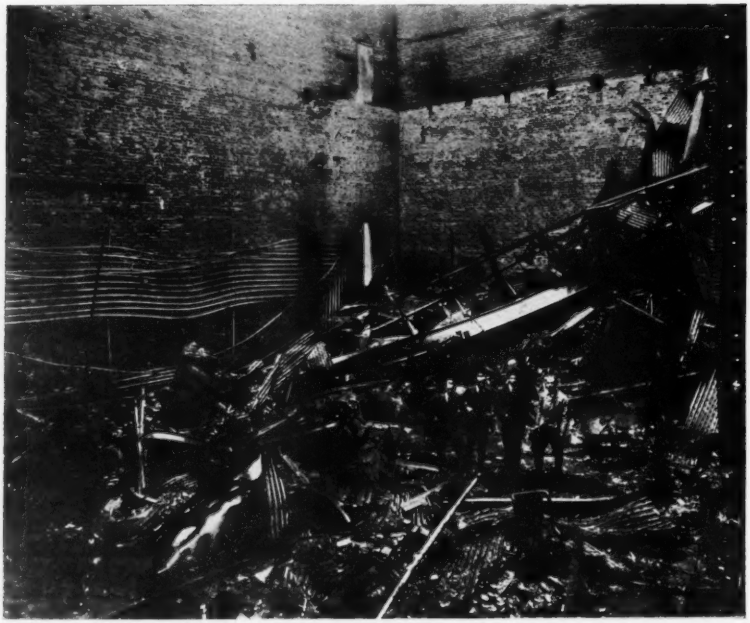
At the time of the fire the building was occupied as a regular theatre, though it had until recently been used for a moving-picture show. Florist stock occupied a small area in a corner of the building. There was no watchman service, but a man slept on the premises. The following defects had been noted in connection with the Inspection Bureau's survey:—defective wiring; no waste cans provided; no signs prohibiting smoking; standpipe and hose not approved; insufficient number of approved chemical extinguishers; unprotected steel in stage section.

View from balcony box to S. W. corner of stage section showing metal beams, loft supports, curtain hanger, roof and floor sheathing upon which floor and roof cinder and concrete were laid.

Story of the Fire.

The cause of the fire has not been determined, but it occurred at 12.50 a. m., on 8th January, 1917, when the man sleeping on the premises was awakened by noise caused by fire, which he thought probably was a horse loose on the stage, used in the play "Old Kentucky." He dressed leisurely, causing considerable delay in turning in the alarm, but when dressed he noticed the flames coming into the auditorium from under the asbestos curtain on the proscenium wall, the draft blowing the curtain beyond the wall line into the auditorium side. The telephone on the stage was inacessible on account of the heat. Another telephone was in the office, but the man turning in the alarm did not know how to operate the intercommunicating switch. When the fire department arrived, they turned four streams onto and through the curtain. The curtain and support fell later; the heat radiating into the auditorium, set fire to and burned practically all the furniture.

The presence of a great quantity of scenery on and above the stage, together with lumber and newly-painted scenes, created a very great heat, causing in most places all the iron and steel beams, girders and other supporting parts to yield to the heat and to fall into the basement with the 4-inch cinder and concrete roof and loft floors, leaving in the stage portion little remaining but the four



View from balcony box to N. W. corner of stage section, showing metal supporting beams, loft floors and roof material where fire was hottest.

walls. The rear wall shows a crack about twenty feet long and the south wall slight cracks: the west, north and proscenium walls are badly burned on inside.

The Superintendent of Buildings has ordered the top twenty feet of the west wall taken down. The walls and floors of the main building are practically intact, except some windows and sash in roof house. The roof of the main building is only slightly damaged.

On the first alarm, sufficient apparatus responded to furnish six single streams, and on the second alarm sufficient apparatus to make in all nine single streams and one siamese six-way stream from steamers, at 200 lbs. pressure, with 2½-inch tip. About 6,000 feet of hose were laid and in active use.

Lessons of the Fire.

The loss would in all probability have been materially reduced by attention to any of the following matters:—

Fire alarm service should be readily accessible.

All steel and iron work should be protected by concrete, terra cotta, tile or brick.

In all public theatres and play houses, a standard automatic sprinkler system should be installed, especially in stage portion.

Accumulations of unnecessary combustible material should not be permitted.

Approved watch service should be maintained.

Big Department Store Fire at Hartford, Conn.

The $750,000 fire which on the night of 29 January, 1917, destroyed the G. Fox and Co. Department Store and the Woolworth Five and Ten Cent Store on the east side of Main Street, Hartford, and caused heavy damage to the adjoining store of the Brown Thompson Co., was with one exception, the most disastrous, from a financial point of view, in the history of the city. The cause is unknown, but coming as it did at the end of a series of incendiary outbreaks, the origin of the fire is shrouded in suspicion. The first alarm was given at 11.12 p. m. by an outsider through a public alarm, but simultaneously the A. D. T. central station received a fire signal from a watchman in the employ of Fox and Co. This company employed four watchmen, who reported hourly from seventeen stations to the central station; but although the records show that a watchman must have passed the point of origin within ten minutes of the outbreak, the fire was already widespread when discovered.

Description and Occupancy of Buildings.

The buildings affected were located in the central "shopping" district, on the east side of Main Street, in the block between Temple and Talcott Streets. This block had a frontage on Main Street of about 375 feet, the greater part of which was divided between the Brown Thompson and the Fox Co.s' stores. The Woolworth store had a small frontage near Talcott Street.

The Fox store comprised several buildings, built at various times, without interior fire walls. The greater part of these buildings can be seen in Photo No. 1; they extend from the one-story and basement Woolworth building on the left, to the Brown Thompson store, which is the large building immediately beyond the temporary props on the right. There was also a five-story structure extending in the rear of the Woolworth store to a front on Talcott Street. All these buildings were of brick and their interior construction presented many undesirable features. Stairs and elevators were open; walls and partitions had continuous hollow spaces; and there were unprotected steel beams, cast-iron posts, etc. The occupancy was congested, and there were stocks of packed furniture and other light material.

The Brown Thompson building is a five-story and basement structure with stone-faced brick wall, and ordinary joist, plaster sheathed floors and partitions. The basement and two lower floors are occupied as a department store, but there are numerous offices and apartments on the three upper floors. A large open light well, with skylight above, extends from the third floor to the roof, and in

Photo No. 1.

this are located sprinkler risers with floor control valves and 2-inch hose at each floor connected to a 4-inch vertical pipe. In the rear of the main building is a one-story and basement annex, having a high-pitched metal-covered roof (wood sheathed inside), with ordinary thin glass in the monitor, but wired glass in the first floor windows. This extended about 40 feet north in the rear of the Fox store.

Exposures.

At the rear, the Fox buildings faced on a twenty-foot alleyway, on the opposite side of which a block of three-story brick tenements on Talcott Street presents a blank wall. Across the same alley is the annex of the Brown Thompson building. Between the Fox and Brown Thompson main buildings a ten-foot alleyway extended from Main Street about 160 feet to the Brown Thompson annex. The windows on either side of this space were thin glass, but the Brown Thompson windows were equipped with open sprinklers of an old pattern. The position of these sprinklers is shown in Photo No. 2.

Story of the Fire.

As has already been said, the fire had gained considerable headway when discovered by the watchman. Although the point of origin cannot be precisely determined, it was certainly either in the basement or on the first floor of the five-story building at the southern end of the Fox store, adjoining the Brown Thompson premises. The best opinion seems to favor the rear of the basement as the seat of the fire. By the time the first fire companies arrived —which they did promptly after receipt of the alarm—the flames had spread to all floors. The destruction of the rest of the Fox buildings

Photo No. 2.

proceeded rapidly and thoroughly, as may be judged from Photo 3, which shows a view of the ruins. Owing to the lack of protective equipment, the spread of the fire in this direction presents no features of interest. The interest centers around the fight to keep the fire out of the main Brown Thompson building to the south, and the annex to the east, of the burning premises.

The entire equipment of open sprinklers on the Brown Thompson store had been put in service shortly after the fire broke out, and these are reported to have worked satisfactorily until the increasing number of hose streams in use reduced the pressure on the

Photo No. 3.

top lines. The fire department was about to use the steamer connections to both open and automatic sprinklers, when, at about 11.42 p. m., the exposing wall fell, stripping the open sprinkler pipes from the building and breaking many windows.

The inside sprinklers operated freely near exposed windows on the three upper floors, no less than 36 heads opening in all. Window frames caught fire at nearly all the windows, and fire entered at one, ran into the hollow ceiling over the fourth floor and spread to the fifth floor, but was confined to a small area by the firemen. The several sprinkler control valves in this area were closed at various times by the firemen, and consequently it is rather difficult to form a judgment upon the efficiency of the sprinklers. It is evident, however, that while they would not have saved the building, they were of great value in holding the fire in check. No fire entered the first and second floors, and owing to the more effective water curtain and hose stream protection no sprinklers opened on these floors.

A fire company with two engine streams was stationed on the upper floors of the building, and kept busy there for twelve hours. When the exposing wall fell they were playing streams from the windows. There were also two ordinary streams and one 1½-inch hose tower stream playing into the alley below. The standpipe hose was used to advantage by the firemen on the upper floors, though it was necessary to collect several lengths of the private hose for one line to reach remote rooms.

The roof of the building, being well protected by a high parapet, was not attacked by fire, but the gravity tank containing the secondary water supply for the sprinkler system and standing on a

Photo No. 4.

steel tower on the northeastern corner walls, almost over the fire, had staves and grillage beams considerably damaged, and was saved only by the strenuous efforts of the firemen with hose streams. For a depth of from 30 to 60 feet, all floors including the basement suffered heavy water damage, this being more widespread in the open sections used by the department store than on the sub-divided upper floors.

Turning to the Brown Thompson annex, we find the wired-glass windows doing good service. Although in two instances the goods immediately behind the windows took fire, the windows themselves

cracked but did not break. The condition of one of them after the fire is shown in Photo No. 4. Owing to their nearness to the ground the intensity of the heat against them was lessened by the upward air draft. The roof was ignited, apparently by direct heat through the metal covering at the cornice; the thin-glass windows in the monitor were broken and fire entered. Fourteen or sixteen sprinklers opened, hose streams were freely used, and the wood sheathing was ripped down. Probably more sprinklers would have opened, had it not been for the hose streams. The damage to the roof was considerable, but its structural safety was not impaired.

A study of the water pressures shows that the water supply was taxed to its utmost. The 16,500-gallon gravity tank affording the secondary supply to the sprinklers was found nearly empty on the morning after the fire. The fact that it became an active source of supply indicates that the waterworks pressure at grade in Main Street must have fallen below 40 pounds, and an examination the same morning of suction gauges on fire engines in the Main Street block, where twelve streams were in operation, showed a pressure of 30 pounds.

The duration of the fire in full intensity was about four hours, but engine companies were on the scene until the following afternoon.

Had the fire not been well handled, a conflagration would almost certainly have ensued; and the whole of the circumstances constitute a compelling indictment of the policy of permitting mercantile buildings of large area and poor construction to remain unsprinklered menaces to the safety of high value districts.

Fire in Uncompleted Factory Building at Cambridge, Mass.

Special Report by T. De V. Martin, Engineer, Underwriters' Laboratories.

This was a spectacular "large loss" fire in an uncompleted factory building to be occupied by a firm of dealers in paper-makers' supplies. The building is located on Commercial Avenue, near a canal from the Charles River Basin. Its area is 177 feet by 95 feet, and it is five stories in height. The frame is reinforced concrete with 8-inch tile and glass panels. For 50 feet from the southern end, the building was provided with concrete floors and had two tile enclosed stairways. This section was separated from the remainder by a 6-inch hard burned tile partition. The rest of the building—the northwestern portion—had 3-inch hard pine flooring on 9 x 14 inch timbers, about 9 feet on centers, with wooden columns.

All floors and the roof deck were completed and the building was being enclosed and equipped progressively upward. Most of the outside wall openings on the first and second floors were glazed with thin glass, and the sprinkler and electrical equipments were being installed. The installation of the light rolled steel frames and

8-inch tile panels was nearly completed on the third and fourth floors, but not on the fifth floor. Some of the forms and supports of the roof frame were still in place. The windows were provided with sectional concrete sills and there was one small scupper in each panel.

Photo No. 1.

There was a tile enclosed elevator shaft near the center of the partition already mentioned, with openings to both sides of this. The automatic swinging tin-clad doors had been installed on the lower floors. A double doorway at each floor beside the elevator shaft was protected by a single pair of three-ply doors. A temporary contractor's elevator was in place alongside the permanent well, with unprotected openings at all floors. An area 9 x 18 feet was left open in all floors for an elevator installation at the second bay on the northeastern side. All exterior doorways on the first floor were open, and some chutes for waste material near the center of the second floor were in place. The contractor's office was located in the northwestern corner of the second floor.

The tenant had been allowed to store a quantity of baled and loose paper scrap in the central areas of the four lower floors.

At about 2.25 p. m., while the work of equipment and structural completion was going forward on all floors, fire was discovered at the bottom of a waste material chute. The cause was admittedly a match or cigarette stub carelessly thrown down the chute. This was just within a large doorway on the first floor, which can be seen through the first window in photo No. 1. A light breeze was blowing, and the fire spread very rapidly in the waste paper on this

Photo No. 2.

floor. The superintendent of construction at once telephoned to the fire department, and, owing to the proximity of the chute to his office, found himself obliged to crawl the entire length of this smoke-filled section until he reached the stairways beyond the tile partition.

The various elevator openings acted as flues, and under the influence of the wind every floor was soon filled with smoke, which drove the workmen to the enclosed stairways without giving them time to carry off most of their tools, clothes, etc. The kindling material in the central sections furnished an intense brief heat which thoroughly ignited the pine flooring. The air supply was abundant and within 15 or 20 minutes the entire structure was a cube of smoke surmounted by a diminishing column of the same. This column was soon shot with long tongues of flame from the small rough supports of the roof forms. The density of the smoke rapidly increased and was soon visible for miles.

The window glass on the northeastern side quickly gave way, and the flames played heavily on this face. The tile partition checked the spread of the flames at first, but much smoke came from the upper stories in the first bay beyond it.

A large amount of apparatus was quickly on the scene, but owing to the large area of the fire, the work of extinguishment was necessarily slow. Barrels of roofing tar and the customary accumulation of rubbish burning fiercely on the northeastern side of the structure hampered the efforts of the firemen.

The effects of the fire on the exterior of the structure are shown in the photos. The most striking results are the excessively warped light sash and the burning through of the heavy roof deck, as shown in Photo No. 2. The concentration of the heat on the northeast side

is apparent from Photo No. 3, showing the extreme warping and falling of the sash, the spalling of the sills and the breaking out of a few tiles at the fourth floor. The spread of the fire through the tile partition where the installation of fire doors had not been completed above the third floor is also shown in this photo by the smoked wall in the eighth bay. The concrete on this side showed a slight flaking of the exterior smooth finish only.

Photo No. 2.

Satisfactory photos of the effects of the fire at the tile partition were unobtainable owing to the poor light. The fire doors at this point on the first two floors were closed at the doorway and elevator well, but whether manually or automatically could not be determined. Those on the third floor were not all in place, and it was here that the fire secured an entrance into the concrete section. The doors had no vents cut in the tin covering and therefore "ballooned" until a seam opened. One elevator door showed a bulge of 6 inches from the core before being vented by the opening of a seam. The partition was subjected to a blowpipe action at the temporary elevator openings at the center, and the tile showed the usual loss of the fire side at this point. On the third floor the breakage extended to the further face and a small area had fallen out. This was probably the result of the action of hose streams, as there was little evidence of great heat beyond.

The unprotected steel I-beams carrying the floor timbers in front of the elevator well sagged from one to three inches at the various floors. The cast iron post caps were cracked in many places,

and many floor planks were burned through at their edges, the columns also being rather deeply burned.

The chief lessons of the fire are: (1) The undesirability of permitting premature occupancy of buildings under construction, particularly in advance of the completion of sprinkler protection, (2) the vulnerable character of wooden flooring of the type used in this building, when attacked by fire with the ample air supply available during construction, and (3) the inadequacy of tile partitions as fire stops after the application of hose streams.

Annual Summary.

Statistics of Fires in Properties Having Automatic Sprinkler Protection.

NOTE.—These tabulations are made at the close of each fiscal year, with the object of furnishing a basis upon which the virtue of the automatic sprinkler as an extinguishing agent can be estimated.

Section I is devoted to fires in which the behavior of sprinklers was, for the reasons given, unsatisfactory.

Section II is a statistical record of all reports of sprinkler fires in the files of the Association upon which the information obtained is sufficiently complete for statistical purposes.

In each table the results of the current year ending April 1, 1917, are given, and these are compared with the results of the total twenty-year record ending at that time.

A decrease in the number of fire reports received by the Association has again to be recorded. This decrease is attributable in part to circumstances which caused a considerable temporary reduction in the advices obtained from one important source of information. Arrangements are, however, being made which will, it is hoped, remedy this situation.

It is noteworthy that while the number of fires in which sprinklers operated has been reduced from 1340 to 1262, the number of cases in which the fire was extinguished before sufficient heat was generated to open any sprinklers increased from 269 to 289. It is, of course, impossible to generalize from these figures—particularly when it is remembered that the number of cases in which no sprinklers opened showed a very heavy decrease in last year's tabulation as compared with the preceding record; but this year's change is in the right direction. Unless it be purely accidental, it points to increased vigilance and intelligence in dealing with fires as they occur. The optimistic interpretation finds some support in Tables 1 and 2. The fires occuring in the daytime and discovered immediately by employees are proportionately more numerous than last year. Fires due to bad housekeeping and carelessness are largely night fires.

Notwithstanding the severe losses in sprinklered plants which have recently aroused so much comment, the record of sprinkler failures reported during the year is very favorable. Of the eighteen

failures attributed to the shutting-off of water, it will be noticed that no less than six were the result of poor fire-fighting. This exceptional display of bad judgment, by counterbalancing the marked improvement as regards the merely reckless shutting-off of water, somewhat obscures the satisfactory character of the record as a whole.

A new classification, "Munition Factories," has this year been introduced into Tables 9 and 10. Only recent fires in the munitions industry as it exists today have been tabulated under this heading.

SECTION I.

Summary of Unsatisfactory Sprinkler Fires.

	1916-1917. No. of Fires.	1916-1917. Per Cent.	1897-1917. No. of Fires.	1897-1917. Per Cent.
Water shut off sprinklers	18	47.4	230	27.0
Generally defective equipment	3	7.9	195	22.9
Unsprinklered portions	2	5.3		
Defective heads	..	..		
Defective water supply or supplies	3	7.9	84	9.9
Sprinkler system crippled due to freezing	..	..	18	2.1
Slow operation of dry system or defective valve	..	..	18	2.1
Slow or defective operation of high test heads	1	2.6	15	1.8
Faulty building construction, concealed spaces, vertical openings, etc	..	..	39	4.6
Obstruction to distribution	4	10.5	53	6.2
Hazard of occupancy too severe for average sprinkler equipment	2	5.3	39	4.6
Explosion crippled sprinkler system	..	..	35	4.1
Exposure or conflagration	1	2.6	63	7.4
Miscellaneous	3	7.9	34	4.0
Plugged heads	1	2.6		
Not classified	..	..	28	3.3
Total	38		851	

Special Classification of Fires in which Failure was Due to Water Being Shut off Sprinklers.

	1916-1917 No. of Fires	1897-1917 inc. No. of Fires
Water shut off for unknown reason, neglect or carelessness	4	92
Water shut off before fire was out or fire rekindled	6	38
Water shut off due to accidents or repairs	3	37
Water shut off to prevent freezing	3	39
Water shut off, probably incendiary	1	11
Water shut off, leaky dry system	..	3
Water shut off, miscellaneous	1	8
Water shut off, defective gate valve	..	2
Total	18	230

SECTION II.

Annual Revision of Sprinkler Fire Tables.

In the following ten tables is given a summary of fires occurring in properties equipped with automatic sprinklers. The total number of such fires reported during the year was 1,551, which includes 289 fires where no sprinklers were opened. Several reports were also received in which the data was incomplete, and these were not used in this summary.

Table No. 1.

Time of Day.

	No. of Fires. 1916-1917.	No. of Fires. 1897-1917 inc.	Per cent of No. with Data Given. 1916-1917.	1897-1917 inc.
6 a. m. to 6 p. m.....	666	9609	53.6	57.8
6 p. m. to 6 a. m.....	577	7026	46.4	42.2
Total with data given..	1243	16635		
No data	19	336		
Total	1262	16971		

Table No. 2.

How Discovered.

	No. of Fires. 1916-1917.	No. of Fires. 1897-1917 inc.	Per cent of No. with Data Given. 1916-1917.	1897-1917 inc.
Employee	699	9828	56.0	59.5
Watchman	159	2540	12.7	15.4
Sprinkler Alarm	274	2539	21.9	15.3
Outsider	56	857	4.5	5.2
Thermostats	40	595	3.2	3.6
Automatic Pump	..	10	..	.06
Supervisory System	21	155	1.7	.94
Total with data given...	1249	16524		
No data	13	447		
Total	1262	16971		

Table No. 3.

Efficiency of Alarm Service 1916-1917.

Note.— This table does not include fires where alarm service does or does not operate promptly if fire is at once discovered by employee — the alarm service having no bearing on such fires one way or the other.

	Satisfactory.		Failure.		Total.
	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	
Watchman alone	87	91.6	8	8.4	95
Sprinkler Alarm alone	140	95.9	6	4.1	146
Thermostats alone	10	90.9	1	9.1	11
Supervisory System alone..	4	100.0	..	..	4

	Watchman.		Sprinkler Alarm.		Thermostat.		Supervisory.		Total.
	Satisfactory.	Failure.	Satisfactory.	Failure.	Satisfactory.	Failure.	Satisfactory.	Failure.	
Watchman and Sprinkler Alarm....	66	62*	117	11	..	..	..	..	128
Watchman and Thermostats	..	1*	..	..	1	..	..	..	1
Sprinkler Alarm and Thermostats	..	..	20	..	16	4	..	..	20
Watchman, Sprinkler Alarm and Thermostats	3	7*	10	..	4	6	..	..	10
Sprinkler Alarm and Supervisory	..	..	37	..	..	..	37	..	37
Watchman and Supervisory	1	1*	..	..	..	..	2	..	2
Watchman, Sprinkler Alarm and Supervisory	6	9*	13	2	..	..	13	2	15
Sprinkler Alarm, Thermostats and Supervisory	..	..	2	..	2	..	2	..	2

Efficiency of Alarm Service, 1897–1917, Inclusive.

	Satisfactory.		Failure.		Total.
	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	
Watchman alone	1470	89.6	170	10.4	1640
Sprinkler alarm alone....	1600	93.8	106	6.2	1706
Thermostats alone.....	180	79.3	47	20.7	227

	Watchman.		Sprinkler Alarm.		Thermostat.		Supervisory.		Total.
	Satisfactory.	Failure.	Satisfactory.	Failure.	Satisfactory.	Failure.	Satisfactory.	Failure.	
Watchman and Sprinklèr Alarm ...	1074	693*	1556	211	..	..	..	..	1767
Watchman and Thermostats	19	7*	..	..	24	2	..	..	26
Sprinkler Alarm and Thermostats	..	..	459	35	377	117	..	..	494
Watchman, Sprinkler Alarm and Thermostats	38	62*	93	7	74	26	..	..	100
Sprinkler Alarm and Supervisory	..	..	184	7	..	..	187	4	191
Watchman and Supervisory	5	5*	..	..	..	..	10	..	10
Watchman, Sprinkler Alarm and Supervisory	53	63*	113	3	..	..	113	3	116
Sprinkler Alarm, Thermostats and Supervisory	..	..	28	1	24	5	29	..	29

* These include fires where sprinkler alarm or thermostats notified the watchman.

Table No. 4.

Number of Sprinklers Operating.

No. of Sprinklers Operating.	No. of Fires. 1916-1917.	No. of Fires. 1897-1917, inc.	Per Cent. of No. with Data Given 1916-1917.	Per Cent. of No. with Data Given 1897-1917, inc.
1	458	5772	37.4	31.5
2	208	3005	16.9	16.4
3	118	1879	9.6	10.3
4	86	1348	7.0	7.4
5	56	871	4.6	4.8
6	40	735	3.3	4.0
7	18	463	1.5	2.5
8	37	477	3.0	2.6
9	19	313	1.5	1.7
10	13	273	1.0	1.5
11	14	240	1.1	1.3
12	21	266	1.7	1.5
13	12	152	1.0	.8
14	7	177	.6	1.0
15	11	143	.9	.8
16 to 20	34	494	2.8	2.7
21 to 25	13	319	1.0	1.7
26 to 30	8	218	.7	1.2
31 to 35	3	136	.2	.7
36 to 40	10	114	.8	.6
41 to 50	12	167	1.0	.9
51 to 75	12	224	1.0	1.2
76 to 100	5	109	.4	.6
Over 100	13	426	1.0	2.3
Total with data given	1228	18321		
Water shut off sprinklers	18	196		
No data	16	278		
Total	1262	18795		

Table No. 5.

Number of Sprinklers Operating.

No. of Sprinklers Operating.	No. of Fires. 1897-1917, inc.	Per Cent. of No. with Data Given. 1897-1917, inc.
1	5772	31.5
2 or less	8777	47.9
3 or less	10656	58.2
4 or less	12004	65.6
5 or less	12875	70.4
6 or less	13610	74.4
7 or less	14073	76.9
8 or less	14550	79.5
9 or less	14863	81.2
10 or less	15136	82.7

No. of Sprinklers	No. of Fires 1897-1917, inc.	Per Cent of No. with data given 1897-1917, inc.
11 or less	15376	84.0
12 or less	15642	85.5
13 or less	15794	86.3
14 or less	15971	87.3
15 or less	16114	88.1
20 or less	16608	90.8
25 or less	16927	92.5
30 or less	17145	93.7
35 or less	17281	94.4
40 or less	17395	95.0
50 or less	17562	95.9
75 or less	17786	97.1
100 or less	17895	97.7
Over 100	426	2.3
Total with data given	18321	
Water shut off sprinklers	196	
No data	278	
Total	18795	

Table No. 6.

Sprinklers Opened on Wet or Dry Systems.

	No. of Fires. 1916-1917.	No. of Fires. 1897-1917, inc.	Per Cent. of No. with Data Given. 1916-1917.	1897-1917, inc.
Wet System	1038	13274	83.8	80.5
Dry System	200	3216	16.2	19.5
Total with data given	1238	16490		
Water shut off system	18	196		
No data	6	285		
Total	1262	16971		

Table No. 7.

Primary Water Supplies to Sprinklers Opened.

	No. of Fires. 1916-1917.	No. of Fires. 1897-1917, inc.	Per Cent. of No. with Data Given. 1916-1917.	1897-1917, inc.
Waterworks	695	8504	57.1	51.7
Gravity Tank	228	4424	18.7	26.9
Pressure Tank	243	2596	19.9	15.8
Automatic Steam Pump	46	913	3.8	5.52
Automatic Electric Pump	6	10	.5	.061
Steamer Connection	0	3	..	.019
Total with data given	1218	16450		
Water shut off system	18	196		
No data	26	335		
Total	1262	16981		

Table No. 8.

Effect of Sprinklers.

	No. of Fires. 1916-1917.	No. of Fires. 1897-1917, Inc.	Per Cent. of Whole. 1916-1917.	Per Cent. of Whole. 1897-1917, Inc.
Practically or entirely extinguished	884	12194	70.05	64.88
Held fire in check	340	5750	26.94	30.59
Total successful	1224	17944	96.99	95.47
Unsatisfactory	38	851	3.01	4.53
Total	1262	18795		

Table No. 9.

Showing Effect of Sprinklers by Class of Occupancy.

	Extinguished Fire.		Held Fire in Check.		Total Satisfactory.		Unsatisfactory.		Total No. of Fires.
	No.	%	No.	%	No.	%	No.	%	
Agricultural Implements	45	60.8	26	35.1	71	95.9	3	4.1	74
Automobile and Bicycle Factories	61	60.4	34	33.7	95	94.1	6	5.9	101
Awning Factories	5	100.0	..	....	5	100.0	..	..	5
Bag Factories	5	62.5	3	37.5	8	100.0	..	..	8
Bakeries	33	70.2	12	25.5	45	95.7	2	4.3	47
Basket Factories	7	100.0	..	....	7	100.0	..	..	7
Bolt, Nut and Screw Works	11	73.3	4	26.7	15	100.0	..	..	15
Boot and Shoe Shops	391	74.5	114	21.7	505	96.2	20	3.8	525
Bottling Works	4	100.0	..	....	4	100.0	..	..	4
Braiding Mills	6	85.7	1	14.3	7	100.0	..	..	7
Breweries	5	83.4	1	16.6	6	100.0	..	..	6
Broom Factories	8	61.5	3	23.1	11	84.6	2	15.4	13
Brush Factories	9	81.8	2	18.2	11	100.0	..	..	11
Button Manufactories	19	90.5	2	9.5	21	100.0	..	..	21
Candle Factories	4	50.0	4	50.0	8	100.0	..	..	8
Candy Factories	61	74.4	20	24.4	81	98.8	1	1.2	82
Canning Works	7	70.0	2	20.0	9	90.0	1	10.0	10
Car Houses	22	48.9	18	40.0	40	88.9	5	11.1	45
Car Works	54	65.9	26	31.7	80	97.6	2	2.4	82
Carpet Mills	112	59.0	69	36.3	181	95.3	9	4.7	190
Carriage Factories	84	66.7	35	27.8	119	94.5	7	5.5	126
Celluloid (Pyroxylin Plastic)	87	69.0	23	18.3	110	87.3	16	12.7	126
Cement and Plaster Works	2	66.7	..	....	2	66.7	1	33.3	3
Cereal Mills	26	68.4	8	21.1	34	89.5	4	10.5	38
Chemical and White Lead	37	55.2	26	38.8	63	94.0	4	6.0	67
Clothing Factories	407	80.1	94	18.5	501	98.6	7	1.4	508
Coffee and Spice Mills	34	72.3	13	27.7	47	100.0	..	..	47
Coffin Factories	34	79.1	8	18.6	42	97.7	1	2.3	43
Cold Storage Plants	4	50.0	4	50.0	8	100.0	..	..	8
Cooperage Plants	41	54.7	25	33.3	66	88.0	9	12.0	75
Cordage Works	175	66.0	81	30.6	256	96.6	9	3.4	265
Cork Factories	7	53.9	4	30.7	11	84.6	2	15.4	13
Corset Factories	5	55.6	3	33.3	8	88.9	1	11.1	9
Cotton Ginnery	10	66.7	5	33.3	15	100.0	..	..	15
Cotton Mills	2932	61.2	1807	37.7	4739	98.9	54	1.1	4793
Cotton Warehouses	94	44.8	95	45.2	189	90.0	21	10.0	210
Cotton Seed Oil Mills	36	53.8	21	31.3	57	85.1	10	14.9	67
Cutlery and Tools	8	53.3	6	40.0	14	93.3	1	6.7	15
Department Stores	277	79.6	60	17.2	337	96.8	11	3.2	348
Distilleries	6	75.0	2	25.0	8	100.0	..	..	8

Table No. 9—Continued.

	Extinguished Fire.		Held Fire in Check		Total Satisfactory.		Unsatisfactory.		Total No. of Fires.
	No.	%	No.	%	No.	%	No.	%	
Drug Houses	110	80.3	23	16.8	133	97.1	4	2.9	137
Dry Cleaning Establishments	4	80.0	1	20.0	5	100.0	..	..	5
Dyeing, Bleaching and Finishing	90	48.7	85	45.9	175	94.6	10	5.4	185
Electrical Appliances	92	76.7	25	20.8	117	97.5	3	2.5	120
Electric Light and Power Plants	2	40.0	2	40.0	4	80.0	1	20.0	5
Elevators, Grain	20	38.5	17	32.7	37	71.2	15	28.8	52
Excelsior Factories	21	80.8	4	15.4	25	96.2	1	3.8	26
Fertilizer Plants	14	60.8	7	30.4	21	91.2	2	8.8	23
Flax and Linen Mills	15	44.2	19	55.8	34	100.0	..	..	34
Flour and Grist Mills	41	56.2	26	35.6	67	91.8	6	8.2	73
Forge and Smithy	11	78.6	3	21.4	14	100.0	..	..	14
Foundries	97	55.4	69	39.4	166	94.8	9	5.2	175
Furniture Factories	354	64.3	150	27.2	504	91.5	47	8.5	551
Garages	42	66.7	19	30.1	61	96.8	2	3.2	63
Garbage Reduction Plants	3	60.0	1	20.0	4	80.0	1	20.0	5
Gas Plants	2	100.0	..	....	2	100.0	..	..	2
Glass Works	34	60.7	18	32.2	52	92.9	4	7.1	56
Glove Factories	7	87.5	1	12.5	8	100.0	..	..	8
Glue Factories	4	57.2	1	14.2	5	71.4	2	28.6	7
Harness and Fancy Leather	49	81.7	11	18.3	60	100.0	..	..	60
Hat, Fur	35	67.3	12	23.1	47	90.4	5	9.6	52
Hat, Straw	9	52.9	8	47.1	17	100.0	..	..	17
Hatters' Fur Mfg	6	54.5	5	45.5	11	100.0	..	..	11
Ice Plants	1	100.0	..	....	1	100.0	..	..	1
Incandescent Lamp Factories	10	58.8	7	41.2	17	100.0	..	..	17
Insulated Wire Factories	22	66.7	11	33.3	33	100.0	..	..	33
Jewelry Shops	92	87.6	9	8.6	101	96.2	4	3.8	105
Junk Shops	4	80.0	1	20.0	5	100.0	..	..	5
Knitting Mills, Cop Yarn	38	60.3	19	30.2	57	90.5	6	9.5	63
Knitting Mills, Full Process	381	63.9	192	32.2	573	96.1	23	3.9	596
Laundries	23	59.0	14	35.9	37	94.9	2	5.1	39
Lead Pencil Factories	11	73.3	4	26.7	15	100.0	..	..	15
Linseed Oil Works	11	55.0	8	40.0	19	95.0	1	5.0	20
Machine Shops	203	65.3	92	29.6	295	94.9	16	5.1	311
Match Factories	41	73.2	11	19.6	52	92.8	4	7.2	56
Mattress Factories	201	74.4	65	24.1	266	98.5	4	1.5	270
Mercantile	547	79.0	128	18.5	675	97.5	17	2.5	692
Metal Reduction Works	3	75.0	1	25.0	4	100.0	..	..	4
Metal Workers	449	64.4	214	30.7	663	95.1	34	4.9	697
Miscellaneous	212	68.4	83	26.8	295	95.2	15	4.8	310
Morocco Leather Shops	9	39.1	11	47.8	20	86.9	3	13.1	23
Motion Picture Theatres	15	75.0	5	25.0	20	100.0	..	..	20
Munition Factories	3	30.0	4	40.0	7	70.0	3	30.0	10
Musical Instrument Factories	81	68.6	33	28.0	114	96.6	4	3.4	118
Oil Clothing Factories	8	72.7	3	27.3	11	100.0	..	..	11
Oilcloth and Linoleum Works	21	27.6	39	51.3	60	78.9	16	21.1	76
Oil Refineries	4	50.0	4	50.0	8	100.0	..	..	8
Packing House and Slaughter	57	64.0	29	32.6	86	96.6	3	3.4	89
Paint and Color Works	105	72.4	35	24.1	140	96.5	5	3.5	145
Paper Box and Papeterie	81	75.0	26	24.1	107	99.1	1	0.9	108
Paper Mills	242	51.2	184	38.9	426	90.1	47	9.9	473
Patent Leather Works	6	40.0	7	46.7	13	86.7	2	13.3	15
Picture Frame Factories	31	64.6	13	27.1	44	91.7	4	8.3	48
Plumbers' Supplies	11	78.6	3	21.4	14	100.0	..	..	14
Potteries	36	65.5	17	30.9	53	96.4	2	3.6	55
Printing and Lithographing	330	79.1	74	17.8	404	96.9	13	3.1	417
Pulp, Miscellaneous	6	26.1	12	52.2	18	78.3	5	21.7	23
Pulp, Soda	1	20.0	1	20.0	2	40.0	3	60.0	5
Pulp, Sulphite	15	40.5	15	40.5	30	81.0	7	19.0	37

Table No. 9—Concluded.

	Extinguished Fire.		Held Fire in Check		Total Satisfactory.		Unsatisfactory.		Total No. of Fires.
	No.	%	No.	%	No.	%	No.	%	
Restaurants	12	85.7	2	14.3	14	100.0	..	..	14
Rice Mills	..	....	1	100.0	1	100.0	..	..	1
Rolling, Wire and Tube Works	14	48.3	14	48.3	28	96.6	1	3.4	29
Roofing Works	11	38.0	17	58.6	28	96.6	1	3.4	29
Rubber Cloth Factories	11	57.9	8	42.1	19	100.0	..	..	19
Rubber Reclaiming Works	3	27.3	7	63.6	10	90.9	1	9.1	11
Rubber Works	80	52.0	67	43.5	147	95.5	7	4.5	154
Saw and Planing Mills	59	41.9	46	32.6	105	74.5	36	25.5	141
Shirt Factories	30	81.1	7	18.9	37	100.0	..	..	37
Shoddy Mills	141	65.6	59	27.4	200	93.0	15	7.0	215
Silk Mills	33	67.4	13	26.5	46	93.9	3	6.1	49
Skin Mills	2	66.7	1	33.3	3	100.0	..	..	3
Soap Manufacturing	21	80.8	4	15.4	25	96.2	1	3.8	26
Stamping and Sheet Metal Works	29	58.0	16	32.0	45	90.0	5	10.0	50
Starch and Glucose Mills	9	50.0	3	16.7	12	66.7	6	33.3	18
Sticky Fly Paper Factories	3	75.0	1	25.0	4	100.0	..	..	4
Sugar Refineries	13	68.4	6	31.6	19	100.0	..	..	19
Tanneries	31	51.7	24	40.0	55	91.7	5	8.3	60
Tenant Manufacturing	358	71.3	120	23.9	478	95.2	24	4.8	502
Theatres	33	78.6	8	19.0	41	97.6	1	2.4	42
Tobacco Factories	37	66.1	16	28.6	53	94.7	3	5.3	56
Trunk Factories	8	72.7	3	27.3	11	100.0	..	..	11
Varnish Works	4	57.1	1	14.3	5	71.4	2	28.6	7
Wall Paper Factories	11	73.3	1	6.7	12	80.0	3	20.0	15
Warehouses	161	68.8	59	25.2	220	94.0	14	6.0	234
Waste and Batting Mills	177	65.8	84	31.2	261	97.0	8	3.0	269
Waste Paper and Rag Shops	25	67.6	11	29.7	36	97.3	1	2.7	37
Weaving Mills	80	62.5	44	34.4	124	96.9	4	3.1	128
Whip Factories	3	60.0	2	40.0	5	100.0	..	..	5
Window Shade Factories	8	88.9	..	....	8	88.9	1	11.1	9
Woodworkers, Class A*	103	53.1	66	34.0	169	87.1	25	12.9	194
Woodworkers, Class B*	96	48.5	81	40.9	177	89.4	21	10.6	198
Woodworkers, Class C*	85	58.6	51	35.2	136	93.8	9	6.2	145
Woodworkers, Class D*	67	58.8	33	28.9	100	87.7	14	12.3	114
Woodworkers, Class E*	80	61.5	43	33.1	123	94.6	7	5.4	130
Woodworkers, Class F*	27	64.3	12	28.6	39	92.9	3	7.1	42
Woolen Mills	724	70.8	248	24.2	972	95.0	51	5.0	1023
Wool Storehouses	22	73.3	6	20.0	28	93.3	2	6.7	30
Worsted Mills	35	50.0	23	32.9	58	82.9	12	17.1	70
Total Sprinkler Fires	12,194		5,750		17,944		851		18,795

*NOTE—The Woodworkers are classed as follows:

Class A. Interior woodwork, builders' supplies (including veneer works).

Class B. Box Factories (including cigar boxes).

Class C. Miscellaneous Woodworkers. Steam power tenant woodworkers (also woodworkers where there is a lack of detailed information as to class).

Class D. Sash, Door and Blind Factories.

Class E. Hard Wood Turning (wheels, pipes, novelties, bobbins, spools, etc., last and wood heel factories).

Class F. Pails and Woodenware. (Plates, wooden bowls, tubs, etc.)

Table No. 10.

Classification of Unsatisfactory Sprinkler Fires by Occupancy.

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of high test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Miscellaneous.	Not classified.	Total.
Agricultural Implements.	2	..	..	..	..	..	..	..	1	..	..	..	..	3
Automobile and Bicycle.	2	1	..	..	..	..	..	2	..	..	1	..	..	6
Bakeries	..	1	..	..	..	..	..	..	..	..	..	1	..	2
Boot and Shoe Shops...	6	2	2	..	..	1	..	1	..	2	5	..	1	20
Broom Factories	2	..	..	..	..	..	..	..	..	..	..	..	..	2
Candy Factories	..	..	..	..	..	..	1	..	..	..	..	..	..	1
Canning Works	..	..	..	..	..	..	..	..	..	..	1	..	..	1
Car Houses	1	1	1	..	1	..	..	1	..	..	..	..	..	5
Car Works	..	1	..	..	..	..	..	1	..	..	..	..	..	2
Carpet Mills	4	1	3	..	..	..	..	1	..	..	..	..	..	9
Carriage Factories	..	1	2	..	1	..	..	1	..	..	2	..	..	7
Celluloid (Pyroxylin) ..	..	..	2	1	1	..	1	..	7	3	1	..	..	16
Cement and Plaster Works	..	..	..	..	1	..	..	..	..	..	..	..	..	1
Cereal Mills	..	2	1	..	..	..	..	..	..	1	..	..	..	4
Chemical and White Lead	1	1	..	..	..	..	..	..	..	2	..	..	..	4
Clothing Factories	3	..	1	..	..	..	2	1	..	..	..	..	..	7
Coffin Factories	..	..	..	1	..	..	..	..	..	..	..	..	..	1
Cooperage Plants	1	3	..	..	..	1	..	3	..	..	1	..	..	9
Cordage Works	2	3	1	..	..	..	..	2	..	..	..	..	1	9
Cork Factories	1	..	..	..	..	..	..	..	..	1	..	..	..	2
Corset Factories	..	..	..	..	..	..	..	..	..	..	1	..	..	1
Cotton Mills	21	13	6	..	..	1	4	1	..	..	..	4	4	54
Cotton Warehouses	12	1	2	..	..	..	1	3	1	..	..	1	..	21
Cotton Seed Oil Mills ..	2	3	2	..	..	..	..	..	..	..	..	2	1	10
Cutlery and Hardware..	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Department Stores	4	3	..	..	..	..	..	1	..	..	2	..	1	11
Drug Houses	..	..	..	..	..	..	..	..	..	..	3	1	..	4
Dyeing, Bleaching and Finishing	3	2	1	..	..	1	..	1	..	..	1	..	1	10
Electrical Appliances ...	1	..	1	..	..	..	..	..	..	..	..	..	1	3
Electric Light and Power Plants	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Elevators, Grain	..	3	3	..	1	..	2	1	1	1	2	..	1	15
Excelsior Factories	..	..	1	..	..	..	..	..	..	..	..	..	..	1
Fertilizer Plants	1	..	..	..	1	..	..	..	..	..	..	..	..	2
Flour and Grist Mills ...	..	1	..	..	..	..	1	..	..	2	2	..	..	6
Foundries	6	1	1	..	..	..	..	..	..	1	..	..	..	9
Furniture Factories	11	12	2	3	..	..	2	9	6	..	2	..	..	47
Garages	1	..	..	..	..	..	..	1	..	..	..	..	..	2
Garbage Reduction Plants	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Glass Works	1	1	..	..	..	..	..	..	..	..	..	..	2	4
Glue Factories	1	..	..	..	..	..	..	..	1	..	..	..	..	2
Hat, Fur	1	2	1	..	1	..	..	..	..	..	..	..	..	5
Jewelry Shops	2	1	..	1	..	..	..	..	..	..	..	..	..	4
Knitting, Cop Yarn	..	1	3	..	..	..	..	1	..	1	..	..	..	6
Knitting, Full Process ..	6	9	5	1	1	..	..	..	..	1	..	..	..	23

Table No. 10—Continued.

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of high test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Miscellaneous.	Not classified.	Total.
Laundries	1	..	..	..	..	..	..	1	..	..	..	..	..	2
Linseed Oil Works	..	..	..	..	..	..	..	..	..	1	..	..	..	1
Machine Shops	11	3	..	..	..	..	..	1	..	1	..	..	..	16
Match Factories	2	..	..	..	..	..	..	..	1	..	..	1	..	4
Mattress Factories	2	1	..	..	..	..	..	1	..	..	..	..	..	4
Mercantile	7	2	..	1	1	..	1	..	..	..	4	..	1	17
Metal Workers	12	12	2	..	..	..	1	..	1	1	2	1	2	34
Miscellaneous	2	3	2	..	1	..	2	..	2	..	2	1	..	15
Morocco Leather Shops.	..	2	..	..	..	..	1	..	..	..	..	..	..	3
Munitions Factories	2	..	..	..	..	..	..	..	..	..	..	1	..	3
Musical Instrument Factories	..	3	..	..	..	..	..	..	..	..	1	..	..	4
Oilcloth and Linoleum Works	..	3	..	..	..	..	1	1	11	..	..	..	..	16
Packing House and Slaughter	1	1	1	..	..	..	..	..	..	..	..	..	..	3
Paint and Color Works	1	2	1	..	..	..	1	..	..	..	..	..	..	5
Paper Box and Papeterie	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Paper Mills	9	16	4	2	..	2	2	..	1	1	2	5	3	47
Patent Leather Works	1	..	..	..	..	..	1	..	..	..	..	..	..	2
Picture Frame Factories	1	2	..	..	..	..	..	1	..	..	..	..	..	4
Potteries	..	..	..	1	..	..	..	..	..	1	..	..	..	2
Printing and Lithographing	4	4	1	..	..	..	..	..	..	..	3	1	..	13
Pulp, Miscellaneous	1	1	2	..	..	..	..	..	..	1	..	..	..	5
Pulp, Soda	2	1	..	..	..	..	..	..	..	..	..	..	..	3
Pulp, Sulphite	3	1	..	..	1	1	..	..	..	..	..	..	1	7
Rolling, Wire and Tube Works	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Roofing Works	..	..	..	..	..	..	..	..	..	1	..	..	..	1
Rubber Reclaiming Works	..	..	..	..	..	..	1	..	..	..	..	..	..	1
Rubber Works	3	..	..	1	..	..	..	..	2	1	..	..	..	7
Saw and Planing Mills	8	7	1	..	3	1	6	2	1	..	4	1	2	36
Shoddy Mills	5	1	5	..	..	3	..	..	..	..	..	1	..	15
Silk Mills	1	1	..	..	..	..	..	..	..	1	..	..	..	3
Soap Manufacturing	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Stamping and Sheet Metal Works	..	2	1	..	1	..	..	..	..	..	1	..	..	5
Starch and Glucose Mills	..	..	..	..	..	..	..	..	1	5	..	..	..	6
Tanneries	1	..	..	2	..	..	..	..	..	..	1	..	1	5
Tenant Manufacturing	7	5	2	..	1	..	1	1	..	..	6	..	1	24
Theatres	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Tobacco Factories	1	1	..	..	..	..	..	..	..	..	1	..	..	3
Varnish Works	..	..	1	..	..	..	..	..	1	..	..	..	..	2
Wall Paper Factories	..	..	1	..	..	..	..	1	..	..	1	..	..	3
Warehouses	8	2	1	..	1	..	..	2	..	..	..	..	..	14
Waste and Batting Mills	1	3	1	..	..	1	..	1	..	..	..	1	..	8
Waste Paper and Rag Shops	..	1	..	..	..	..	..	..	..	..	..	..	..	1

Table No. 10—Concluded.

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of fire test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Miscellaneous.	Not classified.	Total
Weaving Mills	1	1	1	1	..	..	..	..	..	..	..	..	..	4
Window Shade Factories	..	..	..	..	..	..	..	..	1	..	..	..	..	1
Woodworkers, Class A*.	5	8	..	..	..	..	..	5	..	2	3	2	..	25
Woodworkers, Class B*.	5	6	2	..	..	1	1	1	..	2	2	1	..	21
Woodworkers, Class C*.	3	3	1	..	..	..	..	2	..	..	..	..	..	9
Woodworkers, Class D*.	1	5	..	1	..	..	..	..	..	1	3	3	..	14
Woodworkers, Class E*.	3	1	..	..	1	..	2	..	..	..	..	..	..	7
Woodworkers, Class F*.	2	..	..	..	..	..	..	1	..	..	..	..	..	3
Woolen Mills	10	14	10	1	..	2	3	..	..	..	3	4	4	51
Wool Storehouses	..	2	..	..	..	..	..	..	..	..	..	..	..	2
Worsted Mills	2	3	2	1	..	..	..	..	..	..	..	2	2	12
Total Unsatisfactory Fires	230	196	83	18	18	15	38	52	39	34	63	34	31	851

* See detailed classification of woodworkers as given in note under Table No. 9.

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